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THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XLIII.—*Geology of the Little Colorado Valley;** by LESTER F. WARD.

THE geology of the Grand Canyon region of northern Arizona has received much attention on the part of geologists and considerable has been written on the higher beds of Mesozoic age that lie to the eastward in Marble Canyon and farther north, but very little study seems to have been made of the Little Colorado Valley above the point at the north end of the Colorado Plateau, where it broadens out into a plain. The strata of the Grand Canyon up to and including the junction of the Little Colorado with the Colorado River, consist, as all know, entirely of Paleozoic and pre-Paleozoic rocks, and it is the Carboniferous limestones, or sometimes sandstones (Upper Aubrey), that occupy the surface of both the Colorado and the Kaibab plateaus. But the entire system dips sensibly to the northeast and at any point some distance back from the canyon remnants of Mesozoic rocks occur for many miles before reaching the bed of the Little Colorado. That river, therefore, practically flows for almost its entire length over Mesozoic strata, but these do not attain their great development except on the northeastern slope of the valley. Here they form several series of terraces, rising one above another as one recedes from the river, and forming at their maximum development lofty and picturesque escarpments, with brilliantly colored stratification, rivaling in many respects the Grand Canyon itself. The broad arid plains that lie to the southwest of these cliffs have received the name of the Painted Desert, from the circumstance that from any point on this desert these painted cliffs are always in full view. From a great distance they may

* Published by permission of the Director of the United States Geological Survey.

under certain conditions appear beautiful and innocent, but any attempt to invade this desert or to scale these cliffs, except by means of the few well known Indian trails, is certain to be met with defeat, and the hardships that have to be endured in striving to traverse this region are of the severest kind. Lieut. Ives described the region in the following language:

"The scene was one of utter desolation. Not a tree nor a shrub broke its monotony. The edges of the mesas were flaming red, and the sand threw back the sun's rays in a yellow glare. Every object looked hot and dry and dreary. The animals began to give out. We knew that it was desperate to keep on, but felt unwilling to return, and forced the jaded brutes to wade through the powdery impalpable dust for fifteen miles. The country, if possible, grew worse. There was not a spear of grass, and from the porousness of the soil and rocks it was impossible that there should be a drop of water. A point was reached which commanded a view twenty or thirty miles ahead, but the fiery bluffs and yellow sand, paled somewhat by distance, extended to the end of the vista. Even beyond the ordinary limit of vision were other bluffs and sand fields, lifted into view by the mirage, and elongating the hideous picture. The only relief to the eye was a cluster of blue pinnacles far to the east that promised a different character of country. It was useless, however, to take the risk of proceeding directly thither. The experience of the day had demonstrated the hopelessness of trying to drive the mules for any length of time through an untrodden and yielding soil, and it was determined, as a last chance, to go back to Flax River and ascend the bank, at the hazard of having to make a long circuit, till some Indian trail should be encountered leading in the desired direction, and affording a beaten way practicable to be followed."*

Very little seems to be known of the more detailed nature of these deposits. They are usually spoken of as a single great system of beds, and I am not aware of any serious attempt to subdivide them or arrange them into anything like a successive series of varying deposits. It was my chief object during my entire stay in that country to subject these deposits to a searching analytical study and to work out, if possible, their true succession. I began this study by a reconnaissance of the Little Colorado Valley. After making camp at Tanner's Crossing, which is only 12 miles above the point where the Little Colorado enters the limestone canyon at the foot of Coconino Point, I set about mastering the details of the stratigraphy of that general region. Later on, and in the

* Report upon the Colorado River of the West, explored in 1857 and 1858 by Lieutenant Joseph C. Ives, Washington, 1861, Part I, p. 117.

light of information thus obtained, I studied the various remnants of the Mesozoic that are scattered over the Colorado Plateau, and especially Red Butte, which is the most conspicuous and best known of these remnants. Finally, as a concluding task, I returned to the upper portion of the valley of the Little Colorado and made a study of the formation there similar to that which I had made below.

I will not introduce here the details of this investigation and shall be obliged to omit a great amount of important data, including many sections recorded in my note-book, but I will merely give the most general and essential results and the general section.

First of all, let me say, that I think I have succeeded in dividing the formation into three entirely distinct series or classes of deposits. One of these, the thickest of them and the one which is best known, has already been named by Major Powell the Shinarump.* This, however, occupies the central portion of the beds in their geological sequence. The other two divisions are, so far as I am aware, unnamed and I have ventured to give names to them. The lower beds I, therefore, designate as the Moencopie beds, from having first found them in their full development at the mouth of the Moencopie Wash. To the other or highest of the series I have thought it appropriate, from the considerations already set forth, to give the name of Painted Desert beds.†

The Moencopie Beds.

These occupy the lowest portion of the formation, having a maximum observed thickness of between 600 and 700 feet. They present several distinct phases, but the greatest part of them consists of dark reddish brown, soft, laminated, argillaceous shales, nearly destitute of silica, highly charged with

* Geology of the Uinta Mountains, etc., 1876, pp. 68–69. See Twentieth Ann. Rep. U. S. Geological Survey, Pt. II, p. 318.

† The name "Painted Desert" occurs, apparently for the first time, in the contents to Chapter IX of Part I of Lieut. Ives's Report upon the Colorado River of the West, pp. 15 and 113, but is not used in the description of the desert on pp. 116–117, from which the above extract is taken. It is used by Dr. Newberry in Part III, on pp. 76–83, and to it he devotes a section. These early uses of the term show that it refers to an area lying opposite to the region between Wolf's Crossing and Winslow, but Dr. Newberry says (p. 76) "that the peculiar physical aspect and geological structure of the Painted Desert prevail over a wide belt of country bordering the Little Colorado on the east, and extending at least as far northward as our Camp 73." This camp appears from the very imperfect map accompanying the report to have been about on the latitude of Tanner's Crossing, but far to the westward. On this map the Painted Desert is represented as occupying all that region lying along the southwestern base of the painted cliffs from the line of their route through the gap at Blue Peaks and Pottery Hill northwestward to an indefinite distance. On the latest Land Office maps, however, it seems to be restricted to that portion of the desert lying north of the Moencopie Wash and along the base of Echo Cliffs. There seems to be no good reason for thus restricting it.

salt* and gypsum, tending on exposure to assume the character of nearly homogeneous marls and to form low ridges, buttresses and even isolated knolls or buttes, at the bases of cliffs and in eroded valleys. The gypsum often forms thin sheets which appear as fine white lines and which do not follow the planes of stratification but cross the beds irregularly and also cross one another, giving the exposures a peculiar striped appearance.

Between these beds of shale there occur, usually at more than one horizon, brown sandstones. These are more or less argillaceous and their exposed faces do not present sharp angles but have rounded forms, due in the main to the influence of winds which wear off the jagged appearance but do not tend to form chimneys or assume fantastic shapes. These sandstone ledges, which are very uniform in composition, sometimes have a thickness of 100 feet or more, though such heavy beds are usually interrupted by several layers of the shale.

Toward the lower part of the Moencopie beds the shales gradually become calcareous and there is in nearly all good exposures a horizon of white impure limestone, well laminated in its central portion, but becoming very thin and hard below and finally passing either into the typical shale or into homogeneous marls. The extreme upper and also the extreme lower portions of the Moencopie beds always consist, so far as observed, of the typical dark brown argillaceous shale, and the whole series, wherever the contact can be found, always rests in marked unconformity upon the underlying Paleozoic rock (Upper Aubrey).

* An artesian well was bored at Adamana on the Santa Fe Pacific railroad, eight miles north of the Petrified Forest and in the valley of the Rio Puerco. At a depth of 305 feet water was struck which had sufficient force to rise 19 feet above the surface and discharge 25 gallons per minute. The water was very salt, reported at 3 per cent chloride of sodium, so as to be wholly unfit for any use. Mr. James Swainson, in charge of the work, which was done by the American Well Works of Aurora, Ill., was good enough to send me the "log" (record of boring), which is as follows:

	Feet.
Surface sand and adobe	55
Sandstone	3
Cement gravel	1
Sandstone	29
Water at 88 feet only slightly salt.	
Sandstone	20
Brown shale	43
Red shale	49
Hard brown and blue shale	5
Red shale	70
Sandstone	10
Hard brown shale	20
Intensely salt water at	305

The lower 200 feet of this section clearly belong to the Moencopie beds.

The Shinarump.

This constitutes a vast series with a maximum observed thickness of at least 1600 feet. It presents a number of phases, some of which are so distinct that if studied in only one locality they would naturally be regarded as separate subdivisions, but such a general survey as I have been making points to a certain homogeneity in all these beds, or at least establishes the unmistakable tendency towards the recurrence in any of the phases of features that are prominent in other phases. The Shinarump constitutes the horizon of silicified trunks and there is no part of it in which fossil wood does not occur in great abundance. It also marks the limit of the wood-bearing deposits of this region. For this reason alone, in view of the etymology of the name, I should be justified in extending the Shinarump as far as the fossil trunks occur, and it is obvious from the language used that Major Powell had the upper portions of the formation in view as well as the lower when giving the name, although other geologists in speaking of the Shinarump usually seem to have in mind only those beds which I include under the conglomerate. It is doubtful, however, whether the remainder of the formation has really been studied or carefully observed by others, and I fancy that in dealing with it I am entering upon a sort of geological *terra incognita*.

The Shinarump Conglomerate.—I am using this expression, which is the one most commonly found in works that treat of these beds, in a somewhat comprehensive sense, the necessity for which will be apparent. As thus used this part of the Shinarump occupies the lower half of that series and has a maximum thickness of 800 feet. Although perhaps the most prominent feature of it is the so-called conglomerate, which sometimes is in truth deserving of that name, and contains somewhat large but always well-worn pebbles and cobbles derived from underlying formations, still, it rarely happens that this aspect of the beds constitutes the major portion of them. In the first place the conglomerate tends to shade off into coarse gravels and then into true sandstones. These sandstones are of a light color, contrasting strongly with the dark brown sandstones of the Moencopie beds already described. They are, moreover, always more or less cross-bedded and usually exhibit lines of pebbles running through them in various directions. These are true sandstones, very hard, devoid of alumina, and scarcely affected by the winds, so that their angles are usually sharp and the ledges they form are abrupt and jagged. Although the sandstones proper generally occur lower down, still, there is no uniformity in this arrangement, and sandstones are often found in the middle and con-

glomerates more rarely at the top. But in addition to these the Shinarump Conglomerate embraces other classes of beds. There is a well-stratified layer of thinnish sandstone shales that is often seen immediately under the heavy sandstone cap. Some of these shales have a grayish color and are highly argillaceous. These layers tend to thicken even within the formation itself, but especially farther out, and what is more significant, they often become transformed into a bluish white marl. This condition can be seen between the beds of conglomerate in places where the Shinarump Conglomerate is comparatively thin, as in the lower valley of the Little Colorado, where it is only about 300 feet in thickness. This feature is not very prominent, but at other places, as in the Petrified Forest region where the Shinarump attains its maximum thickness of 700 or 800 feet, this tendency on the part of certain beds to become transformed into marls is the most marked feature of the formation. The marls here occupy much more than half of the beds. They are very varied in color, showing besides the white and blue tints a great variety of darker ones such as pink, purple, and buff. These heavy marl beds, of which there may be several in the same cliff, are interstratified between conglomerates, coarse gravels, and cross-bedded sandstones, all of which taken together form the beautifully banded cliffs that are seen throughout the Petrified Forest, and especially along its northern flank. It thus becomes necessary to include under one designation all of these varying beds, which often change the one into the other even at the same horizon within short distances, and rather than adopt a new name I have preferred to call them all the Shinarump Conglomerate.

It remains to mention certain minor features, which are not universal, but which, nevertheless, have considerable importance. In the lower Little Colorado Valley there occur numerous somewhat calcareous clay lenses, the lime taking the form of bright white stripes, while the clay is usually purple or pink. These are very distinct objects and vary in size from lenses 10 or even 20 feet in length to small lenticular blocks or somewhat oval or even spherical clay balls or pellets. These calcareous clay inclusions are scarcely seen farther to the southeast, but on Red Butte they are well marked and here the clay becomes brilliant red and constitutes a true paint stone. Another fact to be noted in connection with the Shinarump Conglomerate is that at certain localities, and notably on Red Butte, there is at its base a clear indication of a transition to the Moencopie beds. The conglomerates proper are underlain by argillaceous shales closely resembling those of the Moencopie beds, but beneath these is a sandstone ledge which cannot be referred to the lower division, as it is more or less

cross-bedded, possesses considerable grit, and has small clay pellets included in it similar to those of the true conglomerate series, in which I have for this reason included it. This condition of things may be somewhat puzzling from the stratigraphical point of view, but the disadvantage in this respect is much more than compensated for by the evidence that it furnishes in favor of the view that all of these beds really constitute one great system, and as opposed to the view which it may be inferred that certain geologists hold, that the series of beds which I have included under the name of the Moencopie beds belongs to a different system, and are in some way connected with the underlying Paleozoic rocks. This view, in the light of the above mentioned facts is, in my opinion, quite untenable.

The Le Roux Beds.—Under the name of Le Roux beds I include the remainder of the Shinarump, deriving the name from Le Roux Wash,* which enters the Colorado Valley two miles below Holbrook, and on which some 15 miles north of Holbrook this series attains the greatest development that I have observed, probably reaching its maximum of 800 feet. These beds, too, if studied at localities where they are less developed, might be supposed to form several quite distinct subdivisions. Indeed I was of this opinion during most of my stay in the lower Little Colorado Valley, but even before leaving there the proofs of their homogeneity had become abundant.

At least the lower half consists of that remarkable formation in which I found vertebrate bones in 1899 and in which alone thus far vertebrate remains have been observed. I have sometimes designated it as the Variegated Marls, sometimes as the Belodont beds. The distinguishing features of these beds is the presence of great numbers of small buttes, the smaller ones appearing to be blue clay knolls, but the larger ones showing other colors, especially purple, and sometimes several bands of different hues. Almost everywhere at this horizon there exist plains, dotted all over with these remarkable little buttes, varying from 3 or 4 feet to 20 or 30 feet in height, usually isolated from one another and having a form peculiar to them. They are not conical in the true sense of the word, since they do not rise to a point at the summit, but are always rounded off and have the form of a well made haystack, the smaller ones looking like haycocks in a field. These butte-studded plains are of course simply the remains of a plateau or mesa which has

*The name "Leroux's Fork" was given to this wash by Lieut. Whipple's party, who followed it down some distance and encamped at its junction with the Little Colorado on Dec. 5, 1853, this being their Camp 79. See Pacific Railroad Reports, vol. iii, part i, p. 75. The name is written in two words on the Land Office map of Arizona.

been worn away, primarily by the action of water, but for a very long period there can be no doubt that wind has been the more potent agency. There is evidence throughout that entire region that the amount of precipitation was formerly much greater than at present, and in so speaking I do not refer to a very remote date geologically, but to a period which was probably post-Tertiary. Indeed, from the present condition of many of the regions where we know that the early Indians dwelt, and who must necessarily have had access to water, now perfectly dry, with all sources of water so remote that they can no longer be inhabited, it must be inferred that there has been a change in the climate within the period of human occupancy. Certain it is that water is doing very little relatively in this region now, while the agency of wind is conspicuously marked wherever it can produce effects. The peculiar form of these buttes is not such as water could have produced, while it is precisely the form that wind would naturally produce, acting upon the very fine and soft materials, somewhat resembling ashes, that compose these buttes.

Further evidence of this, if any were needed, is found in the fact that in approaching the general escarpment, which bounds these plains, the buttes tend to lose their isolated character and form ridges projecting out from the cliffs. It never happens that an entire valley or plain is covered by a single system of buttes. These systems are separated by wide intervals, often of nearly flat country, but through which it can be easily seen that water once flowed, at least in the form of temporary floods, and in such a manner as to have swept away every vestige of the former plateau, and in crossing which there are encountered one or several wide beds to which the term "wash" is popularly applied. In descending the Little Colorado this condition of things is not met with until within some 8 or 10 miles of the Lee's Ferry road. A large system of buttes is then found extending some 5 or 6 miles down the river and across the plain to the first terrace, a distance of 3 to 5 miles; then occurs the first wash, 2 miles in width, followed by another system of buttes, which is nearly due east of Tanner's Crossing, and in which most of the bones were collected by our party. There is then another wide wash, but the next system of buttes does not reach the river, but trends off in a direction nearly due north. There is still another wash before the great Moencopie Wash is reached, the direction of which is such as to be highly favorable for the preservation of these buttes, and accordingly we find their greatest development, so far as this region is concerned, along the Moencopie Wash. They do not however follow the stream up in the direction of Tuba City, but continue to trend northward along the wide valley that lies to the west of Willow Springs and Echo Cliffs.

The reason why these conditions are not earlier met with in the valley of the river is simply that the river does not follow the line of strike, and these beds, being common to the entire formation, must always occupy the same horizon. Above the point mentioned, therefore, they must be looked for farther in the interior. We found them in fact five miles east of Black Falls, or 25 miles southeast of Tanner's Crossing. The great bend in the river culminating at Winslow keeps these beds constantly so far to the northeast, and in a region where it is so difficult to penetrate, that their exact condition for a distance of over 50 miles is little known. But farther up the river, where they approach somewhat to the region of settlement, they again admit of access, and as already remarked, they appear in great force in the valley of Le Roux Wash. Here they cover an area of nearly 100 square miles and form two great amphitheaters of veritable bad lands, but in which the great variety and symmetry in the form of these buttes and ridges, as well as the variegated and iridescent colors that prevail, render them a magnificent spectacle. They can be seen from the southeast for a distance of 20 miles as a white line. Viewed from the top of the mesa out of which they have been carved, the denudation having been arrested at a particular point, they reveal more completely than at any other place the true character of this formation. In the Petrified Forest the Le Roux beds are also well developed and the variegated marls are found only half a mile east of the Lower Forest. The buttes here are quite large and well developed and bones of the Belodont occur in them. In the northern part of the Petrified Forest region the variegated marls lie somewhat farther to the eastward. What is called the Middle Forest lies in the midst of them, and the petrified wood, as everybody has observed, differs here considerably in its constitution and coloration from that of the upper and lower forests, which lie in the horizon of the conglomerate series.

As was remarked when treating of the conglomerates, these variegated marls are actually found stratified between the sandstones by the transformation of certain shales into marls. If these beds are carefully traced a short distance in the direction of the dip, they will be seen to thicken very rapidly and soon to take on the character of the true variegated marls. As they start from underneath a bed of sandstone which caps the conglomerates, and which does not so readily pass into marl, the buttes that are first formed are usually topped out by a block of this sandstone, and it is necessary to proceed some distance farther in the direction of the dip to reach a point where the sandstones disappear. This however ultimately takes place and the marl beds thicken to such an extent

that they have to be regarded as virtually overlying the conglomerates. In fact, in the bed of the Moencopie Wash, on both sides of which these beds are so well developed, the conglomerates can be seen distinctly passing under the marls.

So much for the variegated marls, which, for the purposes of our expedition, constituted the most important subdivision of the entire formation. But as we have seen, their maximum thickness is about 400 feet and there remain still another 400 feet before we reach the base of the painted cliffs. Throughout the whole of this fossil wood is abundant, but the character of the beds as variegated marls no longer continues. In the lower Colorado Valley, where I know it best, the variegated marls are succeeded by a sandstone ledge at least 100 feet in height, yielding black logs of very fine structure. At this point these sandstone beds constitute an escarpment and form a small terrace, the summit of which is a dip plane. Upon this lie the remains of the next set of beds, which are somewhat remarkable, primarily in being essentially limestones, but they consist mainly of loose material somewhat resembling dried mortar, for which reason I have designated them mortar beds. They are, however, very irregular in structure and contain much impure flint and large flinty stones. In the midst of them there occurs a true limestone ledge, well stratified, succeeded by a continuation of the mortar beds. In the region mentioned these beds extend to the limit of what I regard as true Shinarump, and petrified wood was found above the limestone ledge.

A wider acquaintance with this part of the formation shows that the conditions above described do not hold at all points and may even be regarded as exceptional. Nowhere else except at Black Falls did I find the lower sandstone ledge, and at most other points the limestones gradually supervene upon the variegated marls. In fact, it should be remarked, that not only the variegated marls but also the shales of the conglomerate series, which become transformed into marls, are more or less calcareous; and when we find that the entire upper portion of the Shinarump consists mainly of limestones and calcareous materials, we may regard all of this, including the variegated marls, as virtually a calcareous deposit. If we were to look abroad for its homologue in the Trias of the Old World we would find it in the Muschelkalk, while the conglomerate series might well be compared with the Buntersandstein, and the Painted Desert beds with the Keuper, to which the French term Marnes Irisées is only locally applicable.

In the extensive exposures on Le Roux Wash these relations are brought out with great force. Overlying the true variegated marls which stretch out for a distance of three miles across the broad eroded valley, the limestone series comes in gradually and scarcely differs except in the degree of calcareousness

from the underlying beds, but the limestone ledge is ultimately reached and is sharp and definite. It has a thickness of about 10 feet. Over it lie very heavy beds of calcareous materials beginning as mortar beds, such as I have described, but soon taking on more symmetrical forms, closely resembling the marl buttes of the valley below. The color also changes, and many of the buttes are, in whole or in part, of a deep blue or a lively purple. These constitute here the highest beds of the Shinarump and fossil wood is abundant throughout. Much the same conditions prevail in the Petrified Forest region, but the development is here much less extensive.

The Painted Desert Beds.

It remains to consider the third and highest series of the Older Mesozoic of Arizona. As already stated, these constitute the elevated cliffs that bound the valley of the Little Colorado on the northeast. Although broken through in many places, and practically wanting for long distances, they still constitute what may be regarded as a great wall separating the valley from the region of high mesas that lie in the Moqui and Navajo country. As these beds seem to contain no fossil remains, and as they are throughout the greater part of their extent practically inaccessible from the absence of water, their detailed study has been neglected, and I was able to acquaint myself with them only imperfectly and at a few points.

There is, however, no place where they are better developed than directly east of Tanner's Crossing, where we remained longest, and on several occasions the attempt was made to reach them from our camp and to examine them closely. Enough was learned to justify the positive statement that they consist almost entirely of sandstones, perfectly stratified, the different layers differing mainly in color, thickness, and fineness of structure. The great central portion constituting the escarpment and having a thickness of about 800 feet is, within these limitations, practically homogeneous. The series begins, however, with a bed of orange red sandstone, highly argillaceous, and soft in structure, easily eroded, and readily yielding to the influence of the wind. It has a thickness of about 100 feet and in the lower Colorado region stretches across the broad valley at the base of the escarpment and lies directly upon the uppermost limestones of the Shinarump. Here it forms picturesque and fantastic buttes and chimneys standing out upon the plain. It occurs in the same position overlying the Shinarump on Le Roux Wash and forming the top of the mesa which overlooks the amphitheatres that I have described. It is also seen above the Shinarump series to the east of the Petrified Forest. It is therefore probably safe to assume that this bed is continuous from Echo Cliffs to the boundary line of New Mexico.

Of the painted cliffs, considering the little that is known of them, there seems to be nothing more to say. In looking at these cliffs from a distance it is seen that they are overlain by a white formation, the nature of which it is important to consider. Before we had visited the region, so as to obtain a close view of them, it was natural to suppose that they might constitute Jurassic limestones and that the Triassic system might terminate at the line which separates them from the variegated sandstones. But upon close examination this was found not to be the case, and these white rocks were found to consist of sandstones often very pure and cross-bedded, with scarcely any admixture of marl. These without question constitute the summit of the Triassic system in this region. They are, however, not always white, or at least in some places, as for example in the vicinity of Tuba City, they are underlain by a still thicker bed of soft brown sandstone, which is somewhat argillaceous and easily worn by the wind, forming chimney buttes and ruins. This bed has a thickness along the headwaters of the Moencopie Wash of about 200 feet and is overlain at the highest points by the white sandstones to a thickness of 100 feet more. These sandstones are very porous and all the waters that fall in that region immediately pass through them, but as they approach the summit of the much harder and firmer beds that constitute the lower portions of the series these waters are arrested and come out in the form of springs, sometimes almost of small rivers, along the crest of the cliffs above the Moencopie Wash. It is on one of these springs that the little Mormon town of Tuba City is located, and this is true also of Moa Ave, Willow Springs, and other settlements in that country. Still farther back the Cretaceous lignites and limestones lie unconformably upon these uppermost sandstones of the Trias, and the Jurassic is wanting altogether.

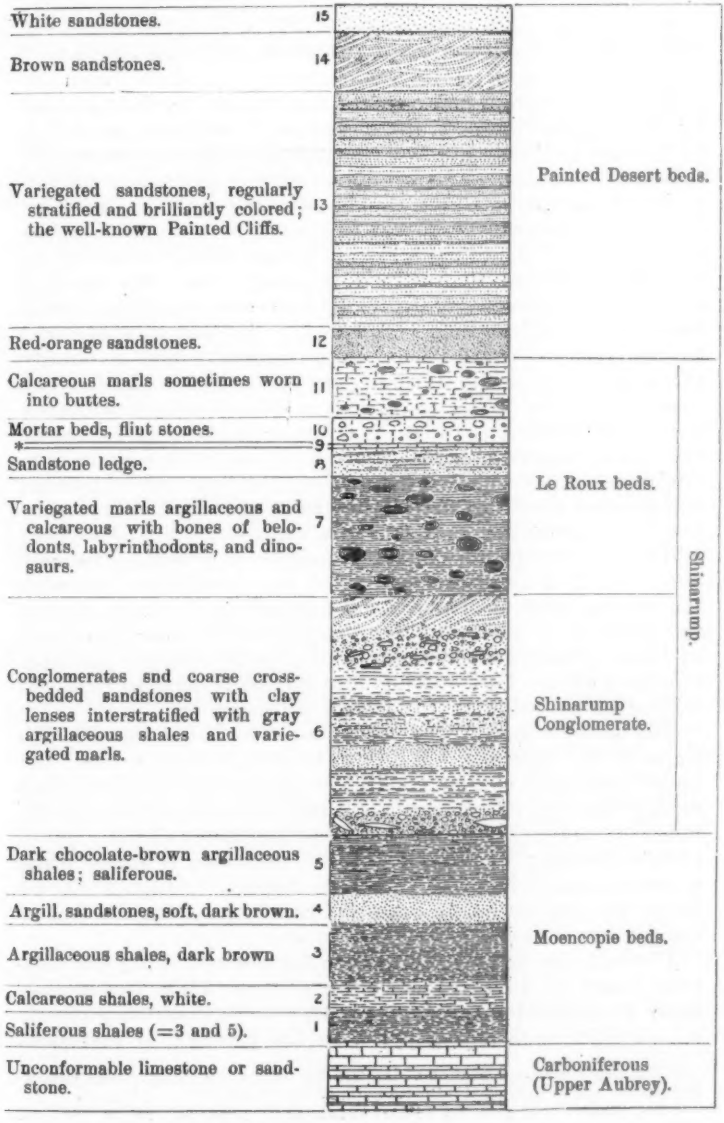
The following columnar section of the strata of the Little Colorado Valley will make the above descriptions more clear.

DESCRIPTION OF THE SECTION. (See page 413.)

	Feet
1. Argillaceous shales	100
2. Calcareous shales	100
3. Argillaceous shales	200
4. Sandstones	100
5. Argillaceous shales	200
Total thickness of Moencopie beds	700

	Feet
6. Shinarump Conglomerate	800
7. Variegated marls	400
8. Sandstones	100
9. Limestone ledge	20
10. Mortar beds	80
11. Calcareous marls	200
Total thickness of the Shinarump	1,600

	Feet
12. Orange red sandstone	100
13. Variegated sandstones	800
14. Brownsand stones	200
15. White sandstones	100
Total thickness of Painted Desert beds	1,200
Total thickness of Trias	3,500


White sandstones. 15
Brown sandstones. 14
Variegated sandstones, regularly stratified and brilliantly colored; the well-known Painted Cliffs. 13
Red-orange sandstones. 12
Painted Desert beds.
Calcareous marls sometimes worn into buttes. 11
Mortar beds, flint stones. 10
*9
Sandstone ledge. 8
Variegated marls argillaceous and calcareous with bones of belodonts, labyrinthodonts, and dinosaurs. 7
Le Roux beds.
Shinarump.
Conglomerates and coarse cross-bedded sandstones with clay lenses interstratified with gray argillaceous shales and variegated marls. 6
Shinarump Conglomerate.
Dark chocolate-brown argillaceous shales; saliferous. 5
Argill. sandstones, soft, dark brown. 4
Argillaceous shales, dark brown 3
Calcareous shales, white. 2
Saliferous shales (=3 and 5). 1
Moencopie beds.
Unconformable limestone or sandstone.
Carboniferous (Upper Aubrey).

* 9. Limestone ledge, definitely stratified.

ART. XLIV.—*On Pyrite and Marcasite;* by H. N. STOKES.*

WHILE pyrite and marcasite are usually readily distinguished by their crystalline form, there remains a residuum, consisting of massive or finely-grained concretionary material, in which this is not possible. The light brass color of pyrite and the tin-white of marcasite, which can be seen when the surfaces are freshly cleaned with acid and compared with standard specimens in a good white light, are not always readily made out in concretions where the surface is rough and the mineral frequently contaminated with other substances. The density too may be misleading. According to Rammelsberg and to my own determinations, pure marcasite has a density of about 4·90,† while that of pyrite is 5·00 to 5·04. The density of even well crystallized specimens of pyrite varies very considerably, and as a criterion of the presence or absence of marcasite is practically worthless, especially in massive or concretionary material. A series of crystallized pyrites, which were shown by the method to be described below to be free from marcasite, gave densities varying from 5·04 to 4·82, while a pyrite concretion, also free from marcasite, gave only 4·56. A. A. Julien‡ has employed the density to determine the relative amount of pyrite and marcasite in mixtures, and on this method he has based the hypothesis that most specimens of these minerals, even when well crystallized, are intimate mixtures of the two, passing into complete paramorphs. It will be shown below that this view is untenable.

The greater rapidity of oxidation is sometimes used to distinguish the minerals. While it is unquestionably true, that under precisely similar conditions marcasite vitriolizes more rapidly than pyrite, conclusions based on this fact have usually failed to take into account the important factor of the ratio of surface to mass; a compact, brilliant, marcasite is stable while a porous mass of pyrite vitriolizes readily. Only when we know this factor can we draw any conclusion from the fact of rapid vitriolization.

Penfield has described a method for distinguishing the minerals, based on the fact that boiling nitric acid liberates sulphur from marcasite but not from pyrite, a method which is clearly not adapted to detecting pyrite in the presence of marcasite.

* This paper is a condensation of Bulletin No. 186 of the United States Geological Survey and is published by permission of the Director.

† The density 4·80 given by Julien (Annals N. Y. Acad. Sci., vol. iv, 1887, pp. 177, 210) is certainly too low.

‡ l. c. pp. 166, 213.

There is no method hitherto known by which even a qualitative determination of the two is possible in mixtures.

In connection with the study of the action of ferric salts on sulphides, I was struck by the quantitative difference of the behavior of pyrite and marcasite, and out of this has been developed the following method for distinguishing them and for determining them quantitatively in mixtures.

That ferric salts oxidize the sulphur of pyrite to sulphuric acid was observed by de Koninck* and the same has since been noted by other observers, without an attempt having been made to follow the reaction quantitatively. The study which I have made of this reaction shows that under uniform and easily controllable conditions the percentage of the total sulphur oxidized is very constant for each mineral, but differs greatly in the two, and in mixtures is an index of the amount of each constituent present. To avoid tedious gravimetric determinations I employ a standard solution of ferric ammonium alum containing 1 gram Fe‴ per liter, with 4 grams free sulphuric acid to prevent the formation of basic salts. An excess of the carefully prepared mineral is boiled with this solution under absolute exclusion of air until the reduction of the ferric salt is practically complete. The reaction may be regarded as taking place in two stages:

(1) $FeS_2 + Fe_2(SO_4)_3 = 3FeSO_4 + 2S.$
(2) $2S + 6Fe_2(SO_4)_3 + 8H_2O = 12FeSO_4 + 8H_2SO_4.$

Since the active mass of the solid phase is constant, it matters not how much mineral be taken for a given volume of the solution provided it be in excess, nor is it necessary to know the absolute quantities of iron and sulphur involved in these reactions, or the strength of the permanganate solution. It suffices, in deducing an expression for the oxidized sulphur, to employ symbols expressing the permanganate equivalent of the iron, and the symbols used represent simply the volumes of permanganate consumed by a given volume of the solution.

For a given volume let

a = iron in the original solution,
b = resulting ferrous iron,
c = resulting total iron.

Then

$c - a$ = increment of iron resulting from decomposition of FeS_2,

and

$$2\left(\frac{31{\cdot}83}{55{\cdot}60}\right)(c-a) = \text{total sulphur in decomposed sulphide.} \quad (A)$$

* Annals Soc. Geol. Belgique, vol. x, 1883, p. 101; Zeitschr. anorg. Chem., vol. xxvi, 1901, p. 123.

Also,

$3\,(c-a)$ = ferrous iron produced according to equation (1)

and

$b-3\,(c-a)$ = ferrous iron produced by oxidation of sulphur.

According to equation (2), 1 atom of sulphur requires for oxidation 6 atoms of ferric iron, producing 6 atoms of ferrous iron: hence,

$$\frac{1}{6}\cdot\frac{31{\cdot}83}{55{\cdot}60}\Big(b-3(c-a)\Big) = \text{sulphur oxidized.} \quad \text{(B)}$$

Calling the percentage of sulphur oxidized p, we obtain from (A) and (B)

$$p = \frac{\frac{100}{6}\cdot\frac{31{\cdot}83}{55{\cdot}60}\Big(b-3\,(c-a)\Big)}{2\left(\frac{31{\cdot}83}{55{\cdot}60}\right)(c-a)} = \frac{8{\cdot}333b}{c-a} - 25.$$

It thus appears that three titrations suffice to determine the percentage of sulphur oxidized, and that neither the amount of FeS_2, the volume of the ferric solution used, nor the absolute titer of the latter or of the permanganate need be known. As, however, the proportion of sulphur oxidized varies with the strength of the ferric solution, the extent of reduction, and the temperature, it is necessary, in order to obtain comparable results, to use a solution of standard composition and a standard temperature, and to continue the action to complete reduction.

The value p, or the percentage of sulphur oxidized, may be called the *oxidation coefficient*. The oxidation coefficient of pyrite, as established by the study of various specimens, varies between 60 and 61 with a mean of 60·4, while that of marcasite varies between 16·5 and 18. In duplicate determinations, properly made, it may differ about one-half unit. It is clear then that in these figures we have perfectly characteristic constants of the two minerals. It may be noted that the figures are independent of any contaminations which do not affect the titer of the solution, or which can be removed by previous treatment.

The explanation of the oxidation coefficient and its difference in the two cases is probably the following: the molecules of FeS_2 are acted on by a reagent which is capable of oxidizing the iron more rapidly than the sulphur. The rate of solution of the pyrite is greater than the oxidation rate of the sulphur, hence a portion of the latter, under the given conditions about 40 per cent, escapes and when once in the free state, as I have found, is scarcely attacked; at the same time the limit of the

oxidation rate of the iron is not reached. Marcasite dissolves much more rapidly, the result being that a still greater portion of the sulphur, about 82 per cent, escapes. The same explanation naturally applies to their different behavior towards nitric acid as observed by Penfield. It is not an indication of the different *chemical* constitution, but of a different solution tension conditioned by different crystalline structure. Doubtless a similar method can be applied in other cases of dimorphism to determining which form is more soluble. I propose to apply the method to distinguishing other dimorphic compounds.

For the details of the operation and apparatus I must refer to the extended article, stating here that the material must be absolutely free from oxidation products, and must therefore be extracted with acid and washed and dried in carbon dioxide, and that air must be rigidly excluded during the operation and complete condensation of the steam provided for. The standard solution oxidizes both pyrite and marcasite much more slowly at 20°, but the per cent of sulphur oxidized is greater, namely about 81 per cent for pyrite and 31 per cent for marcasite.

Doubtless the action of ferric salts plays an important part in nature in the disintegration of pyrite and marcasite, the iron acting as a transferer of oxygen. The conditions under which the sulphur undergoes complete oxidation are as yet not clear, and this subject is now under investigation.

Mixtures of pryite and marcasite.—It is clear that the oxidation coefficient of any given mixture of pyrite and marcasite cannot be deduced by any simple process from the coefficients of the pure minerals. Each mineral is here decomposing in a solution containing the reaction products of the other, and only an extensive knowledge of the influence of concentration, acidity and dissociation would enable us to deduce theoretically a curve for such mixtures. It has therefore been necessary to construct the curve from data obtained by experiments on artificial mixtures. Since the action is a surface action, the result depends, not on the relative weights, but on the relative surfaces, and uniformity in this respect was obtained by always grinding weighed portions of the minerals together. The results, with different preparations and different samples, show that perfect agreement can be obtained in this way, the results for different samples of a given composition not differing more than one-half unit. The following table gives the mean results obtained:

Per cent pyrite,	0	5	10	20	40	60	80	90	95	100
Value of p,	18·0	16·0	15·2	17·1	22·3	29·0	40·3	48·9	52·9	60·5

With these data, a curve is drawn on cross section-paper from which it is possible, after finding the oxidation coefficient of the mixture, to read off the relative proportions of pyrite and marcasite to within 1 per cent when the mixture is quite rich in pyrite and to 2 or 3 per cent when it consists mainly of marcasite. The existence of a well marked minimum in mixtures with 10 per cent pyrite is noteworthy. I have detected similar minima and maxima in curves given by mixtures of pyrite with other minerals. The uncertainty of duplicate values for mixtures with less than 25 per cent pyrite, caused by this minimum, is obviated by mixing the specimen with a known quantity of pyrite and determining the oxidation coefficient of the new mixture. If x represents the percentage of pyrite in the original sample, a mixture of 90 parts of this with 10 parts pyrite will give

$$0{\cdot}9x + 10 = \text{per cent pyrite in new mixture},$$

whence x, composition of the original material, is easily deduced. Here, as before, the results express simply the percentage composition of the iron disulphide, indifferent substances being without effect.

In regard to the influence of impurities, it may be stated that substances which do not contribute iron to, or effect reduction of, the ferric salt are without influence. Pyrrhotite, limonite, siderite, and other soluble iron compounds and zinc-blende or galena in small amounts may be extracted by heating with dilute hydrochloric acid; nickel and cobalt and other iron free sulphides not extractable by acid give abnormal results. For details as to the behavior of impurities reference must be made to U. S. Geological Survey Bulletin No. 186. In this connection, it is interesting to note that in a pyrite carrying 3 per cent copper it is possible to ascertain whether the copper be present as chalcopyrite, or as chalcocite or bornite, a determination which could scarcely be made by the usual analytical methods. The values of p* for a 3 per cent mixture were found to be:

Pyrite-chalcopyrite	62·7
Pyrite-chalcocite	75·9
Pyrite-bornite	76·4

The difference is many times the probable error of a determination.

Small amounts of chalcopyrite mixed with pyrite or marcasite may be readily detected by exposing the sample to bromine

* p is here obtained as before by substituting the permanganate values in the above equation, but in this case it does not represent strictly the percentage of sulphur oxidized.

vapor for half a minute and then to hydrogen sulphide gas; the chalcopyrite is blackened, while the iron sulphide remains bright. I have used the same method to detect and establish the nature of minute grains of chalcopyrite inclosed in rocks.

My examination of various samples of doubtful nature, especially of concretions, shows that the finely fibrous specimens passing as marcasite are very commonly pyrite.

Dr. Julien has very kindly given me a number of the identical specimens of supposed marcasitic pyrite and paramorphs of marcasite after pyrite which were described in his paper.* I have found that those which show regular crystallization are actually pyrite free from marcasite, nothwithstanding their density would lead to the conclusion that they were either pure marcasite or a mixture. So far as my results go, there is no evidence for the existence of such mixtures or that the supposed paramorphs sometimes described are anything more than replacement or incrustation pseudomorphs. I have, however, found a few specimens of marcasite which enclose pyrite which cannot be detected by a lens, and which was probably simultaneously deposited.

A. P. Brown's hypothesis.—A. P. Brown† has published experiments which consisted in heating pyrite and marcasite in sealed tubes at 200° with cupric sulphate solution, according to which marcasite gives up its iron wholly in the ferrous form, while pyrite gives a mixture containing one-fifth ferrous and four-fifths ferric iron. From this he concluded that the iron in marcasite is wholly ferrous, while in pyrite it is four-fifths ferric. I have conducted a series of similar experiments with pyrite and marcasite and cupric sulphate, under the same conditions, in which the greatest care was taken to eliminate oxidation and to determine both ferrous and ferric iron in the solution and the precipitate. My results all agree in indicating that the pyrite is more slowly attacked than marcasite, but that the iron is found as ferrous iron only in the solution, and in the precipitate as ferric iron mixed with cuprous oxide and cuprous sulphide. The results are

For pyrite	62·5—	69·9 per cent ferrous iron
	34·8—	30·1 per cent ferric iron.
For marcasite	58·2—	66·6 per cent ferrous iron
	41·8—	33·4 per cent ferric iron.

It appears therefore, that there is no essential difference between the decomposition products of pyrite and marcasite, while Brown's view requires 20 per cent ferrous iron for

* Annals N. Y. Acad. Sci., vol. iv, 1887, pp. 176, 204.

† Proc. Am. Philos. Soc., vol. xxxiii, 1894, p. 225; Chem. News, vol. lxxi, 1895, p. 179.

pyrite and 100 per cent for marcasite. The relative amounts of ferrous and ferric salts depend simply upon the establishment of equilibrium between the solution and the decomposition products of the pyrite and marcasite, not upon any fundamental difference in the minerals themselves, and the hypothesis in question, while possibly true, is thus far devoid of a valid experimental basis.

As part of an investigation of the reactions involved in the secondary deposition of copper by sulphides, it may be mentioned that cupric chloride at 200° decomposes pyrite according to the equation

$$FeS_2 + 14CuCl_2 + 8H_2O = 14CuCl + FeCl_3 + 12HCl + 2H_2SO_4.$$

Sulphuric acid is also formed by the action of cupric chloride on cupric sulphide and apparently from pyrite and cupric sulphate, so that the oxidation of sulphur appears to be a necessary part of the reaction when certain sulphides are acted on by cupric salts. These reactions, with other salts and sulphides, are still under investigation.

ART. XLV. — *Studies of Eocene Mammalia in the Marsh Collection, Peabody Museum;* by J. L. WORTMAN. With Plates VIII and IX.

[Continued from p. 382.]

The Manus. (Figures 48, 49.) — As compared with the pes, the bones of the manus, especially the metacarpals and phalanges, appear shorter, heavier, and more robust. The carpus contains the eight bones common to the Creodonts. The scaphoid is rather flattened from above downwards; its proximal surface is occupied by an anterior convex facet for contact with the radius, posterior to which there is a roughened area for ligamentous attachment, and a large posteriorly projecting process at the inner posterior angle. Externally there is a

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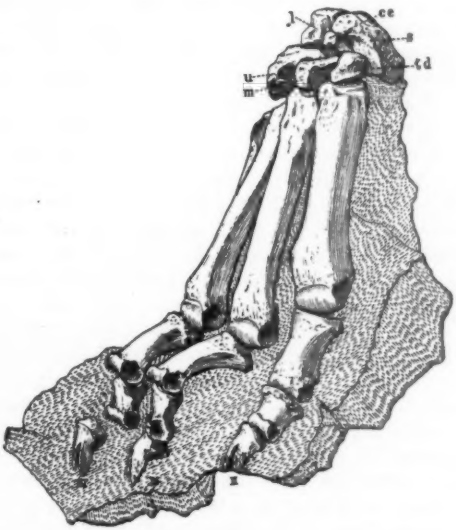

FIGURE 49.—Same foot as in Figure 48, before removal of matrix; side view; one-half natural size.

facet by which it touches the lunar, and inferiorly there are three facets,—an inner lunate, a median rhomboidal, and an outer elongated oval, for articulation with the trapezium, trapezoid, and centrale, respectively.

The lunar is distinct, and of a more or less quadrate form when viewed from in front; superiorly it presents a convex facet for articulation with the radius; internally a flattened

area by which it is closely applied to the scaphoid and centrale; externally a similar area for contact with the cuneiform, and distally a deeply saddle-shaped articular surface, divided by a median antero-posterior ridge into two equal parts, for contact with the unciform and magnum.

The cuneiform is flattened from above downwards and is imperfectly quadrilateral in form, with the postero-external angle much produced, when viewed from above; its anterior and external surfaces are very rugose, presumably for the attachment of ligaments. Superiorly there is a cup-shaped articular depression for contact with the ulna, while behind this is a postero-external facet by which it touches the pisiform. Inferiorly there is an excavated articular surface by means of which it rests on the unciform.

The pisiform, like the other bones, has an unusually rugose surface; it has the usual form and articulation common to the Carnivora, and does not deserve any more extended description.

The unciform is by far the largest bone of the carpus; it rests almost equally upon the fourth and fifth metacarpals, abutting upon the side against the third metacarpal and the magnum, and supports the lunar and cuneiform.

The magnum is relatively small, and is remarkable for its great antero-posterior length as well as the low position of the head,—a form quite unknown elsewhere among the Carnivora. Its articulations are as follows: It rests exclusively upon the third metacarpal; laterally it develops a contact with the head of the second metacarpal and the trapezoid; externally it touches the unciform, and superiorly it supports about equally the lunar and centrale.

The trapezoid is also small in comparison with the other bones of the carpus; it rests upon the second metacarpal, touches the magnum upon its external surface, the centrale and scaphoid above, and upon its internal face exhibits a distinct facet for the trapezium.

The trapezium is a stout ossicle, somewhat larger than in the dog, which articulates with the scaphoid above and the trapezoid and second metacarpal externally. It has an irregular triangular shape, and at its distal extremity bears an oval convex facet for articulation with the metacarpal of the pollex.

The last bone of the carpus which remains to be described is the centrale. This is a small antero-posteriorly elongated ossicle which lies at the junction of the scaphoid and lunar, mainly under the former, and resting about equally upon the trapezoid and magnum. When seen from in front, the bone appears to lie almost exclusively upon the magnum; posteriorly, however, it passes over on the trapezoid to a considerable extent.

The arrangement of the metacarpals, like those of the dog, is on the paraxonic plan; the third projects a trifle beyond the fourth, but the difference is so slight as not to affect materially this order. In like manner, the distal ends of the second and fifth reach about the same level. The actual length of the third is greater than the fourth, in the same way that the second is longer than the fifth, but these differences are counterbalanced by the overlapping of their proximal articular extremities. The overlapping and consequent interlocking of the second with the third, and the third with the fourth, are almost as great as in the metacarpals of the felines and dogs, but the fifth articulates with the fourth by means of a nearly plane, flat face, with little or no interlocking. In size, the second metacarpal is much the largest, having a more or less flattened shaft. The third and fourth have about an equal degree of stoutness, the shaft of the third being a trifle the thicker of the two. The sides of these two bones are considerably flattened laterally, especially in the proximal half of their extent, where they are more closely approximated, but the amount of this compression is much less than in the dog. The fifth is the shortest bone of the four. In the matter of the stoutness of the shaft, however, it is intermediate between the second and third. The distal extremities resemble those of the dog, having well-developed keels confined to the palmar surface. The metacarpal of the pollex is missing and there is no certain means of determining the degree of reduction which it had reached, unless we judge by the size of its articulation with the trapezium. This would seem to indicate that it was small and more or less vestigial, so that the fore foot was essentially tetradactyle.

The phalanges of the proximal row are shorter, broader, and heavier than those of the hind foot. That of the second digit is notably shorter and stouter than the others. The fourth is the most slender, after which follow the third and second. The phalanges of the second row are relatively short and heavy, and exhibit a considerable degree of distal asymmetry. The unguals are rather short and depressed; they are deeply fissured at their extremities and the subungual processes are of moderate size. The ungual foramen is present in all, and is of good size.

Hind Limb.—The pelvis, figure 50, is much damaged and many parts are missing, but enough remains to furnish some of the more important points of its structure. Of the ilium, the region of the sacro-iliac synchrondrosis is present with that of the acetabulum. A considerable portion of the ischium, together with important parts of the pubis, sufficient to give a clear idea of the pelvic outlet, are also preserved. From these

fragments it can be determined that the ilium was of good length and considerably expanded anteriorly, as in *Mesonyx*. The tubercle for the tendon of the *rectus* is large and rugose. The acetabulum is large, of moderate depth, and the acetabular notch is deeply incised. The ischial spine is distinct, the obturator foramen long and narrow, and the pubis comparatively short. This latter fact, taken in connection with the narrowness of the sacrum, figure 51, gives a remarkably small outlet to the pelvis. There is, of course, no means of deter-

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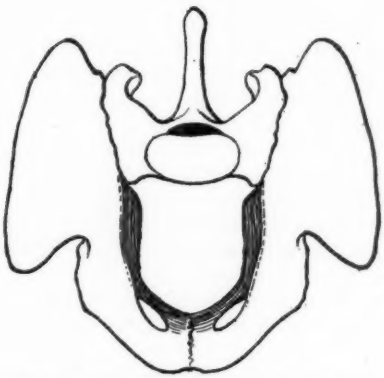
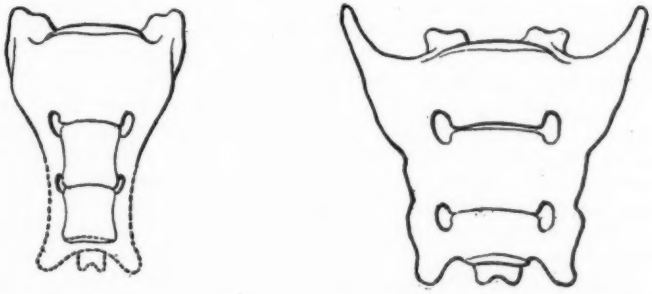


FIGURE 50.—Pelvic outlet of *Dromocyon vorax* Marsh; anterior view; showing dimensions; one-half natural size.

51 52



FIGURES 51, 52.—Sacrum of *Dromocyon vorax* Marsh, and of a Newfoundland dog; under view; showing difference in width; one-half natural size.

mining the sex of the fossil; but assuming it to be a male, if the pelvic outlet in the female were as small in proportion, the young must have been very small at birth. For the sake of comparison, I give in figure 53 an outline drawing of the

pelvic outlet of a male Newfoundland dog, and in figure 52 an under view of the sacrum. The bones of this skeleton are but little larger than those of *Dromocyon*. The difference is certainly very great; this is all the more remarkable, when we remember that the skull of *Dromocyon* is proportionally much larger than that in the dog. If, as before remarked, the females had a proportionally small pelvic outlet, there seems to be no escape from the conclusion that the young were born in a very weak and helpless condition, like the Marsupials, a fact which may have had something to do with their extinction, especially when it is remembered that they were exposed

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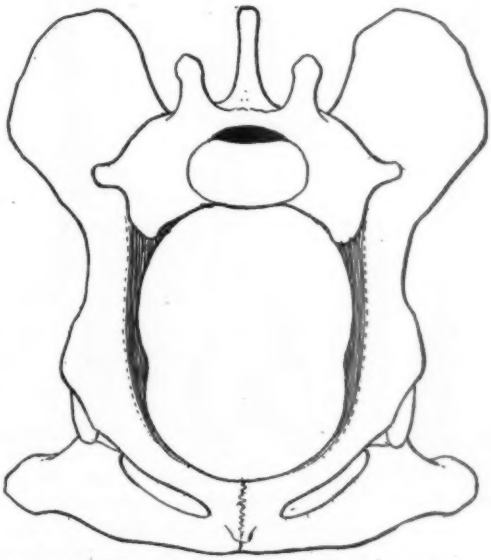
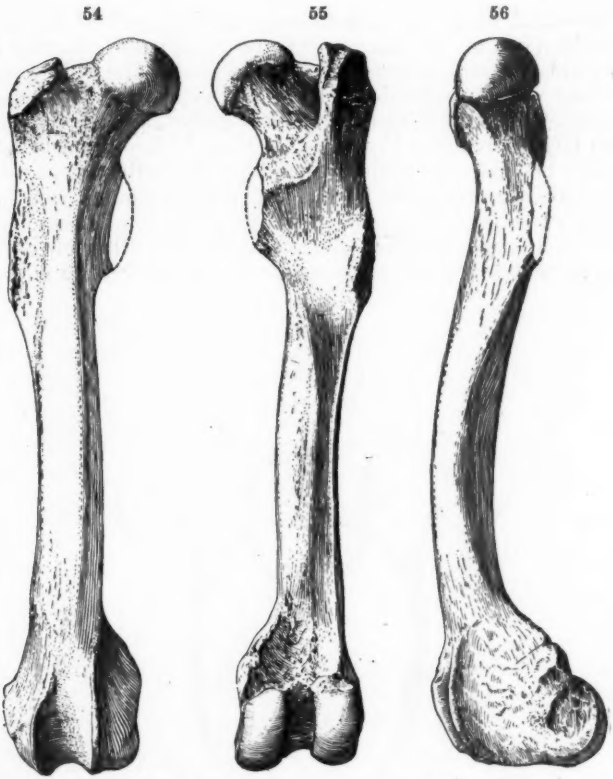


FIGURE 53.—Pelvic outlet of male Newfoundland dog; anterior view; showing dimensions; one-half natural size.

to competition with the rapidly developing contemporary Canids.

The Femur. (Figures 54, 55, 56, 57, 58.) — In all of its essential features, the femur presents a very striking likeness to that of the dog; it is, however, proportionally a little shorter and the shaft has a greater backward curvature. The head is relatively larger, the neck shorter, and the *trochanter major* of greater fore and aft extent. There is a large second trochanter which is placed upon the internal margin of the shaft, and an elongated third trochanter which extends well down upon the outer border. The distal end of the bone is



FIGURES 54, 55, 56.—Femur of *Dromocyon vorax* Marsh; anterior, posterior and side views; one-half natural size. (Type.)

FIGURE 57.—Distal end of femur of *Dromocyon vorax* Marsh; one-half natural size. (Type.)

FIGURE 58.—Head of femur of *Dromocyon vorax* Marsh; end view; one-half natural size. (Type.)

remarkable for the great antero-posterior diameter of the condyles, exceeding the dog in this respect, and quite equaling some of the Artiodactyle Ungulates. There is a distinct popliteal fossa, the inner edge of which is prominent and marked at its lower extremity by an oval facet, for a rather large popliteal fabella. The prominence of this part of the bone indicates unusual strength for the tendinous origin for the outer and inner heads of the *gastrocnemius*, which is well in accord with the cursorial powers of the species. The condyles are subequal in size and the inner projects to a slightly lower level than the outer. There is a deep intercondylar notch leading forward into a well-marked rotular groove.

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FIGURE 59. — Tibia and fibula of *Dromocyon vorax* Marsh; anterior view; one-half natural size. (Type.)

The patella is relatively larger than that of the dog; it is elongated, narrow from side to side, and rather thick from before backwards. The proximal extremity is truncated and roughened for the attachment of the large quadriceps tendon. It has the typical form of a running animal.

The Tibia and Fibula. (Figures 59, 60.)—The tibia, as in the dog, is a trifle shorter than the femur. The head displays two subequal depressions, of which the outer is slightly the larger, to receive the femoral condyles. The spine is bifid, but the separation is not so clearly evident as it is in the dog. The cnemial crest is very large and extends more than half-way down the shaft, whereas in the dog it is limited to the upper third. The upper posterior portion of the shaft is deeply excavated. The inferior extremity exhibits a trochlear surface similar to that of the dog. The internal malleolus is a strong process and the trochlear grooves are pronounced.

The fibula has a relatively stouter shaft than that of the dog, but at the same time is much reduced; it is applied to the lower end of the tibia for a considerable distance. The shaft is triangular above and oval in cross-section below. The distal end is large, and forms a stout external malleolus in the ankle joint; it articulates with the astragalus by means of a lateral facet, and does not touch the calcaneum.

The Pes. (Plate VIII.) — As a whole, the pes is very dog-like in general appearance; the loss of the hallux, the compressed, elongated, and highly interlocking character of the metatarsals, as well as the distinctive "square-cut" aspect of their distal ends, recalls at once the hind foot of the dog. There are, however, some important differences which will be pointed out in the course of this description. The astragalus, if found dissociated from the other parts of the skeleton, and if the head were not so convex from before backwards, might readily be mistaken for that of a Perissodactyle Ungulate. Indeed, it furnishes just such a transitional stage as we may readily believe to have preceded the peculiarly specialized type of this bone in the Artiodactyla. The trochlear surface is deeply grooved, the head is set rather obliquely upon the body by a moderately elongated neck, and its distal end is divided into two unequal facets. Of these the larger is internal, slightly concave from side to side, and articulates with the navicular; while the outer is narrow, much prolonged upon the posterior surface, and articulates with the cuboid. The calcaneal facet is narrow and deeply concave from above downwards, while the sustentacular facet is broad, slightly convex, and more or less pyriform in outline. There is no astragalar foramen. As compared with the astragalus of the dog, the transverse axis of the head coincides more nearly with the transverse plane of the trochlea; the calcaneal facet is narrower, and the sustentacular facet is broader.

60

FIGURE 60.—Tibia and fibula of *Dromocyon vorax* Marsh; end view; three-fourths natural size. (Type.)

The calcaneum has a relatively longer tuber than that of the dog, but otherwise the two agree very closely. The cuboid is proportionally larger than that of the dog. Proximally there is a distinct facet for the astragalus, but otherwise the articular surfaces are much alike in the two. In the posterior aspect, however, they differ considerably; in the dog the cuboid has a double peroneal tubercle, of which the smaller is external and just above the commencement of the peroneal groove, and the other, larger, is located near the center of the posterior surface. The direction of the peroneal groove, which is large, is downwards and inwards. In *Dromocyon* there is but a single large elongate tubercle, occupying nearly the whole of the posterior surface. Beneath the distal extremity of this tubercle is a notch, which is converted into a distinct groove upon the outer surface of the bone, marking the course of the long peroneal tendon. In the dog the tendon passes obliquely

down to its attachment upon the base of the second metatarsal, and the groove is relatively large; whereas in *Dromocyon* it is small, and the tendon passed down to the outer edge of the tubercle, thence turned abruptly inwards to be inserted in the same place. The relatively large size of the peroneal tubercle, which serves principally for the attachment of the calcaneo-cuboid ligament, may be taken to indicate unusual firmness of the tarsal joint.

The navicular has much the same general shape as in the dog, and differs from it in that it is narrower, and its proximal surface more deeply saddle-shaped; it articulates with the cuboid in quite the same way, and distally exhibits the three usual facets for the cuneiformia. Posteriorly it presents some important differences from that of the dog. In the case of the latter, there are two more or less distinct navicular tubercles, separated by a wide sulcus. In *Dromocyon* there is a single tubercle, which is produced into a long pointed process. The three cuneiformia differ from those of the dog, in that they are decidedly higher and narrower from side to side; their manner of articulation is, however, much the same. The internal cuneiform is large and elongate, bearing upon its distal extremity an articular facet for a rudiment of the first metatarsal.

The metatarsals closely resemble those of the dog, not only in their elongate, compressed, and highly interlocking character, but they show a decided tendency towards lateral flattening of their contiguous surfaces. Their distal ends, moreover, exhibit that characteristic "square-cut" appearance so common to the modern Canidæ. The foot is of the strictly paraxonic type, the third and fourth metapodials being of equal length. While the second and fifth are also of equal length, the second is much the larger and stouter bone, the disparity in size being considerably greater than that seen in the dog, and about equal to that of the fore foot. The distal metapodial keels are present and well developed; they are, however, confined to the plantar surface and do not extend more than half-way around upon the dorsal surface.

The proximal phalanges are proportionately shorter, stouter, and more robust than in the dog, but the articular faces have very much the same disposition and extent. Proximally the plantar notch is not so deeply incised as in the phalanges of the dog, but their dorso-plantar curvature appears to be somewhat greater. The median phalanges, or those of the middle row, are proportionately still shorter than those of the first, as compared with the dog. They exhibit a slight degree of distal asymmetry. The unguals are short, rather broad, and deeply fissured.

The following principal measurements are herewith given:

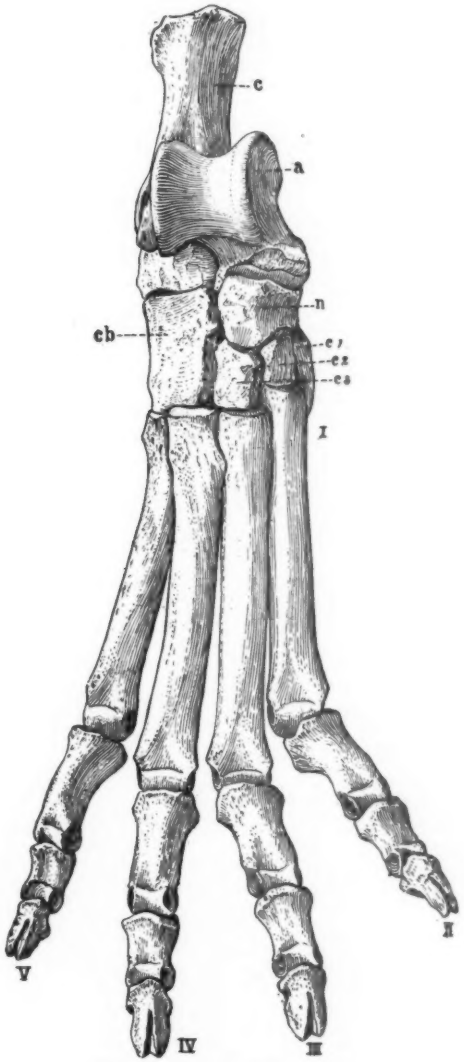
Length of skull	318·5^{mm}
Width of skull at posterior portion of zygomata	160·
Height of anterior nares	54·
Vertical diameter of orbit	43·
Height of occiput above base of condyles	113·5
Width of condyles	54·
Greatest width of occiput	32·
Length of superior tooth line from anterior border of incisors	154·
Length of premolar series	62·
Length of molar series	45·
Antero-posterior diameter of superior canine	20·
Length of lower jaw	248·
Length of inferior dentition	151·
Greatest depth of jaw including coronoid	93·
Depth of jaw opposite first molar	43·
Width of palate between canines	33·5
Width of palate opposite first molar	46·
Transverse diameter between inferior canines (internal)	18·
Transverse diameter between inferior canines (external)	44·
Transverse diameter of inferior canine	13·
Total length of vertebral column, as articulated, including sacrum, exclusive of curves; tail not included	860·
Total length of vertebral column, including curves; tail not included	910·
Length of tail (estimated)	970·
Length of cervicals	230·
Length of dorsals	338·
Length of lumbars	280·
Length of sacrals (estimated)	62·
Length of body of axis, including odontoid	60·
Height of axis at posterior border of centrum	63·
Antero-posterior length of spine of axis	68·
Height of seventh cervical, including spine	113·
Height of first dorsal, including spine	128·
Height of ninth dorsal	64·
Length of body of penultimate lumbar	36·
Width of sacrum	40·
Length of first rib	71·
Length of third rib	132·
Length of seventh rib	169·
Width of third rib	20·
Width of seventh rib	13·
Length of scapula	197·
Antero-posterior diameter of glenoid cavity	38·5

Transverse diameter of glenoid cavity	27·mm
Length of humerus	210·
Transverse diameter of distal end of humerus	35·
Antero-posterior diameter of distal end of humerus	36·
Length of ulna	230·
Length of olecranon of ulna	49·5
Length of radius	174·
Transverse diameter of head of radius	26·
Antero-posterior diameter of head of radius	17·5
Transverse diameter of distal end of radius	36·5
Antero-posterior diameter of distal end of radius	22·
Length of fore foot	152·
Width of carpus	40·
Length of second metacarpal	65·
Length of third metacarpal	75·5
Length of fourth metacarpal	71·
Length of fifth metacarpal	56·
Length of first phalanx, digit II	28·5
Length of second phalanx, digit II	15·
Length of ungual phalanx, digit II	15·
Length of first phalanx, digit III	28·5
Length of second phalanx, digit III	15·
Length of ungual phalanx, digit III	16·
Length of first phalanx, digit V	27·
Length of second phalanx, digit V	13·5
Length of ungual phalanx, digit V	15·
Length of pelvis (estimated)	240·
Depth of pelvis at anterior border of pubic symphysis	64·
Vertical diameter of pelvic outlet	58·
Transverse diameter of pelvic outlet	42·
Antero-posterior diameter of acetabulum	30·5
Length of femur	227·
Transverse diameter of proximal end of femur	51·
Transverse diameter of distal end of femur	42·
Antero-posterior diameter of distal end of femur	49·
Length of tibia	217·
Transverse diameter of head of tibia	44·
Antero-posterior diameter of head of tibia, including cnemial crest	54·
Transverse diameter of distal end of tibia and fibula	39·
Antero-posterior diameter of distal end of tibia	23·
Length of hind foot	235·
Length of tarsus, including the *tuber calcis*	91·
Width of tarsus	32·5
Length of calcaneum	66·
Length of astragalus	49·
Width of astragalus	32·
Length of cuboid in front	25·

Length of second metatarsal	78·5mm
Length of third metatarsal	87·
Length of fourth metatarsal	87·
Length of fifth metatarsal	74·5
Length of first phalanx, digit II	27·
Length of first phalanx, digit III	29·
Length of first phalanx, digit IV	29·5
Length of first phalanx, digit V	26·
Length of second phalanx, digit III	16·
Length of ungual phalanx, digit III	15·5

This specimen is from the volcanic-ash bed of Henry's Fork, Bridger Basin, and was found by J. Heisey.

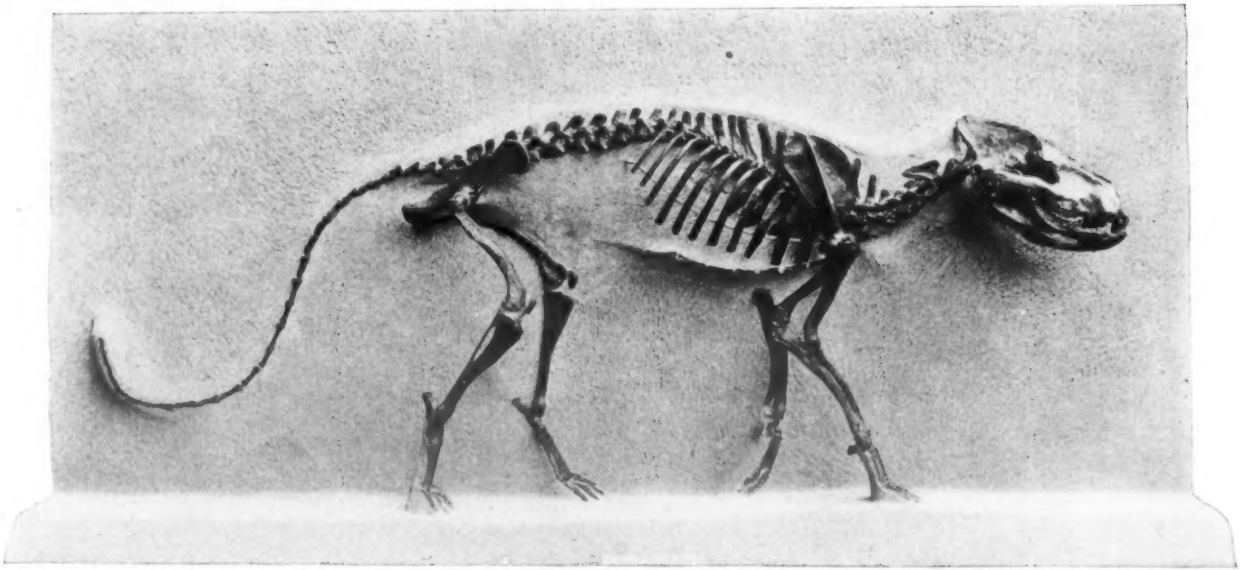
[To be continued.]



EXPLANATION OF PLATE VIII.

Right hind foot of *Dromocyon vorax* Marsh; anterior view; three-fourths natural size. (Type.)

c, calcaneum: *a*, astragalus; *n*, navicular; *c1*, *c2*, *c3*, internal, middle, and external cuneiformia; *cb*, cuboid.



EXPLANATION OF PLATE IX.

Mounted skeleton of *Dromocyon vorax* Marsh; side view; one-twelfth natural size. (Type.)

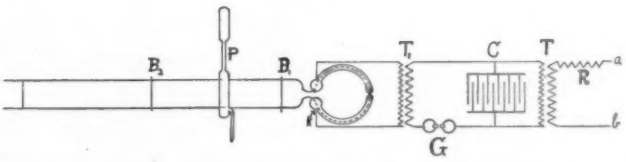
ART. XLVI.—*Dielectric Constant of Paraffins;* by WILL G. HORMELL.

THE following paper presents some experiments in which by means of a modified form of the Blondlot oscillator the dielectric constants of four commercially different paraffins were obtained for 40, 60, and 80 centimeter waves. The paper also contains an investigation of the relative velocities of 80 centimeter waves along magnetic and non-magnetic wires of different diameters. And finally there is given in the table, by way of comparison, the light index of refraction of the different paraffins for the D_1 line as obtained by means of the Abbe refractometer.

Apparatus.

Figure 1 is a diagram of the connections made to the various pieces of apparatus used in the experiment. The terminals

1



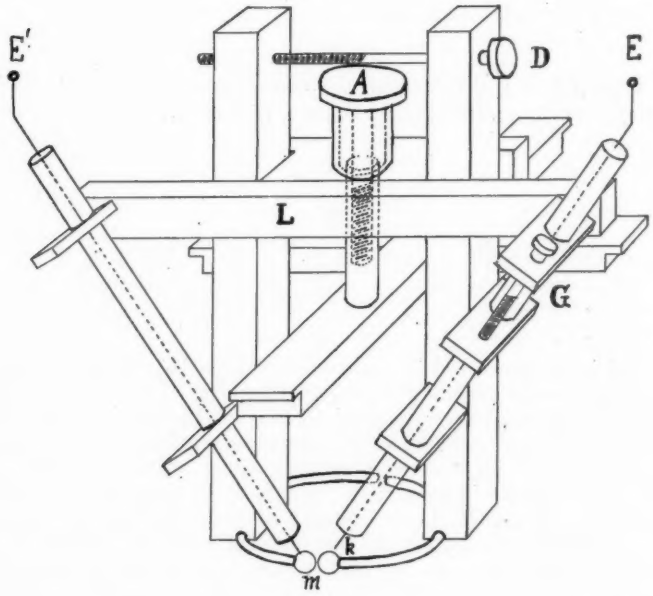
a and *b* are connected to a commercial line delivering an alternating current with a pressure of 52 volts. The resistance R is used to regulate the quantity of current flowing through the circuit. T is a transformer whose primary of about 200 turns is wound around a core of soft iron wire. The secondary of the coil contains about 2000 turns. C is a battery of four Leyden jars each having a capacity of 5900 electrostatic units. T_1 is a Tesla coil made after the formula given by Tesla and is capable, when fed to its full capacity, of giving a ten-inch spark. In all the following experiments a current of about 7 amperes was taken from the commercial line which would give in the Tesla coil a spark of not more than 3^{cm}. G is a spark gap consisting of two small iridium* cylinders inserted in $\frac{3}{4}$-in. brass spheres. The length of the spark gap can be nicely adjusted by means of a screw thread on the axle of one of the spheres.

The constancy of the spark at this gap is of the greatest

* G. W. Pierce, this Journal, vol. ix, p. 256, 1900.

importance in securing the best possible results from the oscillator. A rapidly rotating disc presenting projections to the opposite terminal of the gap gave very indifferent results. Zinc balls, polished brass balls, and brass balls with platinum terminals inserted after the fashion of the iridium cylinders, were used, but none of these gave the constancy secured through the use of the iridium. Platinum terminals gave the next best results, but on account of their rapid deterioration they required almost constant attention in order to keep their surfaces well polished. The iridium gap needs no attention except for occasional adjustment of length.

2



The secondary terminals of the Tesla coil are joined to the primary terminals E′E (figure 2) of the Blondlot oscillator. The remaining portion of figure 1 is shown in detail in figure 3.

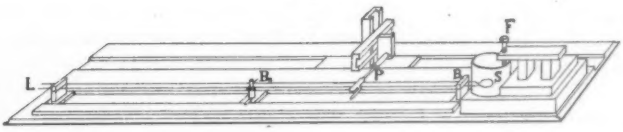
The Blondlot oscillator (figure 2) is the modified form used by W. D. Coolidge.* Some additions, however, have been made in order to bring the adjustments more completely under

* Annalen der Physik, lxvii, p. 578, 1899.

the control of the observer. The two semicircles comprising the primary coil are firmly fastened to two hard rubber uprights which are pivoted on the crossbar L.

The screw D regulates the spark gap m. A spiral spring, not shown in the figure, wound round D, keeps the two uprights separated. The wire E′ is passed through a thick-walled glass tube and is inserted in one of the ball terminals of the primary. The other wire E forms a spark gap at k, which is regulated by the screw G. The glass tubes are held in place by pressure screws not shown in the figure. This framework holding the primary is placed in a 4×5 in. glass jar. Immediately under the primary a secondary of the same

3



diameter is placed, and its terminals are led out through two corks inserted in the side of the jar (figure 3). This coil is firmly held in position by three rubber posts sent up from a rubber plate placed in the bottom of the jar. A mica plate is placed between the primary and secondary, the distance between which is regulated by the screw A (figure 2). The screw-clamp F (figure 3) holds the framework of the primary rigidly in place. When the coils are in use the jar is filled with kerosene.

The first bridge, B_1 (figure 3), rests in a groove in the rubber support. It is 30^{mm} long, 1^{mm} thick and 3^{mm} wide. It has two holes in which to receive the ends of the secondary, and these when in place are soldered to the bridge. Two grooves symmetrically placed are filed on top of the bridge, $1{\cdot}8^{cm}$ apart. The Lecher wires, L, rest in these grooves and are clamped firmly to the bridge by means of the top of the rubber support, which is furnished with two strong brass screws. The other ends of the Lecher wires, $1{\cdot}8^{cm}$ apart, are clamped in a second rubber support. The supports, about 150^{cm} apart, are strong enough to allow a tension of several pounds on the wires. Unless otherwise designated, the Lecher wires are made of No. 18 copper wire.

The second and movable bridge, B_2, is a brass wire 1^{mm} in diameter and 4^{cm} long. The post holding the bridge works in a socket containing a spring which presses the bridge against the two wires. The base of the bridge holder has an index

extending over a meter rod, thus indicating the position of the bridge.

P is a Plücker argon tube mounted in such a way that it may be moved at will along the three mutually perpendicular directions. Tubes filled with other gases were tried but none of these glowed with such brilliancy. Professors John Trowbridge and T. W. Richards* have called attention to the unusual sensitiveness of an argon tube to oscillating discharges. In order to observe the glow of the tube to the best advantage it is necessary to work in a darkened room.

Some Preliminary Experiments.

(*a*) *Determination of the Line Constants.*

In this adjustment of the oscillator the primary was made of copper wire 2^{mm} in diameter and was furnished with discharging balls 4^{mm} in diameter. The diameter of the coil was 4^{cm}. The total length of the secondary, including the leading out wires to the first bridge, was about 25^{cm}. In every case the secondary is made of number 18 copper wire. The wave length given out by such a combination when the primary was $\cdot 3^{mm}$ from the secondary was $61 \cdot 33^{cm}$. In order to determine the exact wave length one may proceed as follows: Place the argon tube under the wires, in contact with them, and about 14^{cm} from the first bridge. Slide the movable bridge along the wires until the first position of maximum glow is reached; this will be $27 \cdot 80^{cm}$ from the first bridge. When the bridge is in the proper position, the maximum glow of the tube may be easily noted from the extension of the glow into the sealing off tube.

Coolidge† found it necessary to connect the first bridge with the earth in order to lead off the irregular vibrations of the oscillator, which otherwise masked the position of the node of the fundamental wave.

I have not found this necessary, however, and attribute it largely to the accurately symmetrical arrangement of the primary and secondary.

Table I contains a set of readings which were taken for the determination of the line constants. In this as in all other cases ten readings were taken in locating the position of a node. The average of two or three such groups for the same node never varied beyond a half of one per cent.

The readings for the nodes most distant from the first bridge are not so concordant, but the percentage of error

* This Journal, vol. iii, p. 19, 1897.

† Annalen der Physik, lxvii, p. 582, 1899.

TABLE I.

1st node.	2d node.	2d node with balance tube.	3d node.	4th node.
27·65^{cm}	58·85^{cm}	58·15^{cm}	89·25^{cm}	120·75^{cm}
27·65	58·95	58·00	89·55	120·45
27·80	59·15	58·30	89·50	120·65
27·75	58·75	58·00	89·50	120·55
27·80	59·00	58·20	89·25	121·00
27·80	58·80	58·20	89·60	120·80
27·90	59·15	58·35	89·55	120·80
27·70	59·15	58·15	89·40	120·50
28·00	58·60	58·10	89·55	120·30
27·95	59·00	58·00	89·75	120·50
27·80	58·94	58·14	89·49	120·60

is no greater. Generally a careful adjustment of the three spark gaps will lead to a more brilliant and a more constant glow of the tube. Frequently for various reasons the tube will cease to glow in the dark. If on these occasions white light from an incandescent lamp or a lighted match be permitted to fall on the tube, it will instantly begin to glow. This is no doubt "the effect of ultra violet light upon the electric discharge" which Hertz* has so thoroughly investigated.

Positive and negative surgings start at the middle of the first bridge and meet in opposite phases at the middle of the second bridge, thus forming, according to Hertz, potential loops at points midway between the two bridges and potential nodes at the middle of the bridges. The distance between the middle points of the bridges is a half wave length, the value of which can be found by adding the distance between the two wires to the scale reading. It is doubtful just what this bridge correction ought to be, but the determination of the wave length by another method (given later) seems to confirm the above correction.

This half wave is not the length of a free half wave along the wires. The presence of the tube has added capacity to the wires and thereby shortened the wave. The tube correction must therefore be determined. To do this find the position of the second node. The table shows this to be 58·94^{cm}.

Now place a tube, which we shall call the balance tube, in contact with the wires at the middle of the second potential loop. The wave is now shortened by an amount which is equal to the tube effect. The balance tube ought to be of the same diameter as the argon tube, but its length is not essential

* Electric Waves, p. 63.

provided it extends beyond the two wires. The balance tube as well as the argon tube ought to be within at least $1\frac{1}{2}^{cm}$ of the middle loop, otherwise the capacity effect is lessened.

One-half of this last reading (i. e. the distance between the first bridge and the second node) will give what may be called *the half tube wave*, in which one node rests on the wires and the other rests on the center of the bridge. We shall call the former the *wire node*, and the latter the *bridge node*. The balance tube may now be removed and the third and fourth nodes located, leaving the argon tube at the first potential loop, though as far as the position of the nodes is concerned the tube may be placed at any other potential loop. If we add the tube effect to the average reading in the second column, and also the distance between the two wires, we shall get what may be called a *wave length in air*. (To this is added also a scale correction of 3^{mm}.) This is, in fact, the length of a free wave along the wires, but since the experiments of Sarasin and De La Rive* have shown that the velocity of a rapidly oscillating electrical disturbance along a wire is the same as that in air, we have good authority for calling the above the *wave length in air*.

The same quantity may be secured by subtracting the first reading from the third and the second from the fourth.

Summary of the line constants.

(1) $58{\cdot}94-58{\cdot}14 = {\cdot}80^{cm}$ = tube effect.

(2) $\frac{58{\cdot}14+{\cdot}3}{2} = 29{\cdot}22^{cm} = \frac{1}{2}$ tube wave.

(3) $58{\cdot}14+{\cdot}3+{\cdot}80+1{\cdot}80 = 61{\cdot}84^{cm}$ = wave length in air.

(4) $89{\cdot}49-27{\cdot}80 = 61{\cdot}69$ = " "

(5) $120{\cdot}61-58{\cdot}94 = 61{\cdot}67$ = " "

$61{\cdot}73$ = average wave length in air.

It will be seen that the wave length in air determined by the first method (3) is very approximately the same as that secured by the second method (4) and (5).

(*b*) *Determination of the Dependence of the Wave Length upon the Distance between the Primary and the Secondary Coils.*

In this experiment the coils were 5^{cm} in diameter. The primary semicircles were made of 3^{mm} wire and had discharging balls 5^{mm} in diameter. The pitch of the screw controling the primary was $1{\cdot}27^{mm}$. The primary was removed and re-

* Archives des Sciences et Naturelles Geneve, 1890, xxiii, p. 113.

placed a number of times in order to test the accuracy with which the relative positions of the coils could be reproduced. In all cases the agreement of the wave lengths was very satisfactory.

TABLE II.

Distance between centers of coils.	Wave length.
2·84^{mm}	89·80^{cm}
3·15	87·25
3·46	84·80
3·77	80·20
4·08	76·10
4·39	73·05
4·69	71·15

Table II shows the results of this experiment. It will be observed that as the distance between the coils increases the wave length decreases, showing that a decrease in the capacity and mutual induction of the system decreases the period of oscillation.

(*c*) *Determination of the Relative Velocities of Electrical Waves along Magnetic and Non-Magnetic Wires of Different Diameters.*

In this experiment the coils were 5^{cm} in diameter and the length of the secondary was 48·5^{cm}. The coils were kept at the same distance and the Lecher wires were changed.

TABLE III.

Kind of wire.	Diameter of wire.	Corrected wave length.
Copper	1·00^{mm}	81·52^{cm}
Copper	2·00	80·84
Copper	3·40	80·80
Iron	1·00	81·70
Iron	1·25	81·56
Iron	1·80	80·36
Iron	2·60	80·86
Copper	1·00	81·08
Nickel	·93	80·90
German silver	1·00	80·88
Brass	1·00	81·10
Copper Secondary	1·00	79·26
Iron Secondary	1·00	79·44

Table III shows the final results. The last two sets of readings shows the comparison of waves produced when the Lecher wires were kept constant and the secondary of the Blondlot oscillator changed. In the first case the secondary was made of copper wire and in the second it was of iron. Great care was taken to make the two secondaries of the same size and shape and to keep the primary and secondary the same distance apart in both cases.

Allowing less than one per cent for error of observations, it is readily seen that the wave lengths for different kinds of wires are practically the same. One concludes from these observations that conductors offer no resistance to the passage of short electrical waves, and that the magnetization of iron is not able to follow oscillations as high as 800,000,000 per second. These conclusions agree with those of Hertz* and Lodge.† But St. John‡ found a difference of wave length in iron and copper of from $1\frac{1}{2}$ to 3 per cent. This difference, however, was for oscillations of 115,000,000 reversals per second.

Dielectric Constant of Paraffin.

Maxwell has shown theoretically that the dielectric constant of a substance is equal to the square of the index of refraction. The index of refraction of a given substance for electrical waves as well as for light waves is the ratio of their relative velocities in air and in the given substance. But since the ratio of the velocity is equal to the ratio of the wave lengths we have

$$K=\mu^2=\left(\frac{\lambda_a}{\lambda_s}\right)^2 \text{ where}$$

λ_a = the wave length of a given electrical disturbance in air.
λ_s = the wave length of the same electrical disturbance in the given substance.
μ = index of refraction.
K = dielectric constant.

The Blondlot oscillator offers a unique and very satisfactory means of measuring the wave length in air and in the given substance. This means is satisfactory because one is able to keep the oscillator in a constant condition, thus making the wave length in air a constant for a given combination. The method of securing the wave length in air has been described, and it now remains to indicate the way in which the wave length in paraffin may be obtained.

* Electric Waves, p. 113.
† Modern Views of Electricity, p. 101, 1889.
‡ Proceedings of American Academy, p. 218, 1894.

Let us suppose that the oscillator is adjusted for a half wave length of about 40^{cm}. Take a block of paraffin 40^{cm} long, 6^{cm} wide and 8^{cm} thick. It can be readily sawed from a commercial cake by means of a table rip-saw. With this same saw make two grooves 1·8^{cm} apart and half way through one side. Bring the block up under the two Lecher wires, making them lie in the grooves and placing the end of the block against the support of the first bridge. Using a hot iron and a piece of paraffin, run the melted wax into the grooves, thus making a solid column around the wires. Place the argon tube between the free end of the column of wax and the movable bridge. When the oscillator is in action and the tube located, it will be noticed that the distance between the end of the column and the bridge is less than the *half tube wave*. The column may now be cut off piece by piece until the *wire node* of the half tube wave rests on the end of the column. The length of the column plus half the distance between the Lecher wires (·9^{cm}) is very approximately the half wave length in paraffin. In the actual experiment the length of this column was 26·4^{cm}. And if to this we add ·9^{cm} we shall get 27·3^{cm} as the approximate wave length. If the base of the apparatus be long enough for three half waves, a column of paraffin 85 or 90^{cm} long ought to be moulded. For this purpose a box was prepared 90^{cm} long, 8^{cm} wide, and 8^{cm} deep, and was lined with tinfoil. It was put together with screws so that it could be easily taken apart. By a suitable contrivance two copper wires 1·8^{cm} apart could be stretched through the middle of the box and made long enough to be fastened in the two supports of the base. The melted paraffin was poured into the box and allowed to cool partially. Then a closely fitting top was placed on the paraffin and the whole subjected to a pressure brought into play by three iron clamps. A gauge inserted in the side of the box recorded the pressure. All this was necessary in order to secure columns uniformly dense and free from air holes. Having a column thus suitably prepared, one must decide two questions before a final determination of the dielectric constant is made.

1st. How much beyond a node may the end of the paraffin column rest without changing the position of the second bridge?

2d. How large in area must the section of the column be in order to include the whole of the effective field surrounding the Lecher wires?

The first question can be quickly answered. Fasten the moulded column between the supports, making one end rest against the first support. It will be about 3^{mm} from the first bridge, since the bridge rests in a groove 3^{mm} from the outer

surface. Putting the argon tube and the movable bridge beyond the column of paraffin, and locating the first external node (the fourth from the first bridge), it will be found that a node (the third) will rest in the column 6 or 8^{cm} from the end. Saw off a 2^{cm} slab from the end of the column and again locate the node. Continue this until the wire node of the half tube wave rests upon the end of the column. Frequent experiments have shown that if the column be as much as 1·5^{cm} too long or too short, the position of the fourth node is not affected. The conclusion, therefore, is that no error will be made if the column of paraffin be 1·5^{cm} too long or too short, or the end be not against the first bridge. This fact makes it very convenient when using the same column for different wave lengths.

This same column of proper length may be used to answer the second question. After the position of the fourth node has been determined, the column may be removed, and by means of the table saw the section reduced to one 6×8^{cm}. The process of locating the node and reducing the section may be continued until the column is too thin to allow further reduction.

TABLE IV.

Size of column.	Area of cross section.	Position of node.	Change in position of node.	Effect on one-half wave length.
7×8^{cm}	56$^{sq.\ cm}$	120·34^{cm}		
6×8	48	120·20		
5×7	35	120·35		
4×6	24	120·28		
3×5	15	120·83	·5^{cm}	·2^{cm}
2×4	8	123·60	3·2	1·1
$1·5 \times 3·5$	5·2	126·68	6·4	2·3
1×3	3	131·14	11·8	4·4

Table IV shows the result of this experiment. From it we learn that the effective field, so far as it can be determined by means of an argon tube, certainly lies within a column whose cross section is 5×7^{cm}. By a comparison of the values in the fifth column with those in the first, we find that the effect on the half wave varies approximately inversely as the square of the distance of the wires from the outer surface.

Four specimens of the paraffin were secured from a wholesale dealer. Thy were known as numbers 120, 125, 130 and 135, their numbers representing their melting point on the Fahrenheit scale. Two columns of each kind were prepared and the melting point on the centigrade scale noted. The density was

determined from four different specimens of each column. The total pressure to which the paraffin was subjected when in the mould was 2140 lbs., or 7 lbs. per sq. in. Moulding the columns under pressure was the only way in which masses of this size could be secured of anything like uniform density. The dielectric constant of a column moulded without pressure differed as much as 3 per cent from that of a column of the same kind of paraffin moulded under pressure.

In Table VI will be found the dielectric constant of two kinds of oil, a paraffin oil and a "transformer oil." This grade of paraffin oil is sometimes used for transformers, but the so-called "transformer oil" is said by the wholesale dealers to be the best oil procurable for transformer work. In order to make the necessary measurements with these oils a telescoping box was made and lined with tinfoil. The ends were constructed of thin rubber plates and through them the Lecher wires were stretched. When the nodes rested on or near the rubber ends the wave length in air was not changed by the presence of the box. The box was filled with oil and the length adjusted until the outer end rested on the third node. The box was also filled with melted paraffin and the temperature effect on the position of the node was noted.

Table V shows how the index of refraction and therefore the dielectric constant increased as the temperature decreased. It is very probable that the change of the dielectric constant can be accounted for on the ground of the change in density. The densities at 79° C. and at 18° C. are given in the table.

TABLE V.

Temperature.	Index of refraction.	Dielectric constant.	Density.
79° C.	1·44(7)	2·09(5)	·764
71 C.	1·45(6)	2·12(5)	
65 C.	1·46(3)	2·14(0)	
56·5 C.	1·47(1)	2·16(3)	
53·7 C.	1·47(5)	2·17(6)	
18 C.	1·48(2)	2·19(8)	·908

In order to illustrate the method by which the dielectric constant of each column for each wave length was determined, I have selected a set of readings at random. They are the data secured for column I of the number 120 paraffin.

Diameter of primary	5·00^{cm}
Length of wave in air	40·85
Length of tube wave	39·24
Length of column	83·00

Position of fourth node.

1st set of readings.	2d set of readings.
121·90	122·10
121·45	121·60
122·05	122·30
122·00	121·70
122·05	122·30
121·65	122·00
122·10	122·05
122·05	122·30
122·40	121·80
122·15	122·50
121·99	122·07

122·07
121·99

122·03
39·24

82·79 = scale reading for position of node.

82·79 = scale reading for position of node.
·30 = scale correction.
·90 = bridge correction.

3) 83·99

27·99 = length of half wave in paraffin.

$\frac{40{\cdot}85}{27{\cdot}99} = \mu = 1{\cdot}46(1)$

$\left[\frac{40{\cdot}85}{27{\cdot}99}\right]^2 = K = 2{\cdot}13(0)$

By a very simple device the primary of the oscillator was replaced by one 4^{cm} in diameter and under this was placed a secondary of corresponding diameter. With this combination the half wave in air was 30·66^{cm}. With a 3^{cm} primary the half wave in air was 20·85^{cm}. By a happy coincidence which was not altogether fortuitous, the columns were long enough to contain within the limit of error three half waves of the 5^{cm} primary, 4 half waves of the 4^{cm} primary, and 6 half waves of the 3^{cm} primary.

Table VI exhibits a comparison of the melting points, densities, indices of refraction and dielectric constants of the paraffins and the two kinds of oils for the three different wave lengths. The dielectric constant of the oils, however, was determined for only one wave length. In the last two columns will be found the light index of refraction for the D line and the corresponding dielectric constant. A comparison of

TABLE VI.

Kind of paraffin.	Observed melting point.	Density.	$1/2\lambda = 40{\cdot}84^{cm}$.		$1/2\lambda = 30{\cdot}66^{cm}$.		$1/2\lambda = 20{\cdot}84^{cm}$.		$\lambda = {\cdot}00005896^{cm}$.	
			μ	K	μ	K	μ	K	μ	K
No. 120	47·6° C.	·894	1·46(2)	2·13(7)	1·47(0)	2·16(1)	1·48(8)	2·21(7)	1·5380	2·3655
No. 125	50·2° C.	·905	1·47(3)	2·18(0)	1·48(9)	2·21(8)	1·50(4)	2·26(2)	1·5430	2·3808
No. 130	53·3° C.	·907	1·48(3)	2·19(8)	1·49(3)	2·22(0)	1·50(2)	2·25(6)	1·5505	2·4044
No. 135	56·2° C.	·897	1·49(0)	2·22(1)	1·50(1)	2·25(4)	1·51(2)	2·28(6)	1·5523	2·4098
									1·5050	2·2650
Paraffin oil	309° flash	·905	1·54(3)	2·38(1)					1·4565	2·1711
Transformer oil		·823	1·48(7)	2·21(3)						

the dielectric constants for any given substance will reveal the fact that in every case there is a gradual increase as the wave length decreases, even including the light wave. These results certainly indicate the analogous behavior of electrical and light waves. A comparison of the dielectric constants of the different paraffins shows that these constants increase with the melting point. From these experiments it seems necessary, therefore, in tabulating the dielectric constant of paraffin, to give its density, its melting point, and the wave length for which the constant was obtained. The third decimal place is bracketed because the accuracy of measurements does not warrant its unqualified use, and yet the quantities of which the tabulated numbers are the average are of such uniformity that some credence must be given to this third place.

Light Index of Refraction.

The light index of refraction was obtained by means of an Abbe* refractometer. This is constructed upon the principle of total reflection and is graduated to read directly the index of refraction of the D_1 line of any transparent liquid or solid which can be placed between its prisms. Films of paraffin were easily procured by floating bits of wax on hot water and allowing the melted wax to solidify. In order to insure close contact, both the film and the prisms were gently heated before the wax was placed before the prisms. The refractometer gave data also from which by means of a table one could calculate the dispersion factor between the D_1 and the F lines.

Having the index of refraction for two lines in the spectrum,

* Physikalischer Praktikum, Wiedemann-Ebert.

one may apply Cauchy's formula and thus obtain the index for infinitely long waves. When the constants A and B of this formula are eliminated, it takes, according to Gordon,* the following form:—

$$\mu_{\lambda=\infty} = \frac{\mu\lambda^2 - \mu_1\lambda^2_1}{\lambda^2 - \lambda^2_1} \quad \text{where}$$

$\mu_{\lambda=\infty}$ = index of refraction for infinitely long waves
μ = " " " a given long wave
μ_1 = " " " a shorter wave
λ and λ represent the corresponding wave lengths.

TABLE VII.

μ_1 for $\lambda = 81{\cdot}64^{cm}$.	μ_2 for $\lambda = 41{\cdot}64^{cm}$.	μ_0 for $\lambda = \infty$.	μ'_1 for D_1 line.	μ'_2 for F line.	μ'_0 for $\lambda = \infty$.
1·46(2)	1·48(8)	1·45(6)	1·5380	1·5567	1·498
1·47(3)	1·50(4)	1·46(2)	1·5430	1·5589	1·509
1·48(3)	1·50(2)	1·47(7)	1·5505	1·5665	1·513
1·49(0)	1·51(2)	1.48(5)	1·5523	1·5684	1·519

Table VII shows the results obtained from the application of this formula to the light indices and also to the electrical indices. The values of the sixth column should agree with those of the third. They should at least be less than the index found for the longest wave. This formula does not appear to fit the experimental facts.

Conclusions.

1. For reversals as high as 800,000,000 per second the velocity of electrical disturbances along magnetic and non-magnetic wires of different diameters is the same, thus showing that the magnetic properties of iron are not able to follow such rapid changes.

2. The effective field around the Lecher wires as far as it can be detected by means of an argon tube, does not extend more than 3^{cm} from the wires, and the effect on the half wave within this region varies approximately inversely as the square of the distance from the wires.

3. The dielectric constant of a given paraffin increases with the density of the paraffin. It increases rapidly from a temperature 20° above the melting point to a temperature 30° below the melting point. Among different paraffins the dielectric constant increases as the melting point of the paraffin increases.

4. The dielectric constant increases as the wave length decreases. It is greater for short light waves than it is for short electrical waves. Cauchy's formula as a means of obtaining the index of refraction for indefinitely long waves does not meet the experimental facts.

Jefferson Physical Laboratory, Harvard University.

* Philosophical Trans., pt. I, p. 441, 1879.

ART. XLVII. — *On Some New Mineral Occurrences in Canada:* by G. CHR. HOFFMANN, of the Geological Survey of Canada. (Communicated by permission of the Director.)

1. *Datolite.*

A specimen of a mineral was recently submitted to the writer for identification, which had been met with by Mr. Bush Winning in some abundance in the workings of the Daisy mica mine on the ninth lot of the first range of the township of Derry, Ottawa County, in the Province of Quebec. This mineral proved, on examination by Mr. R. A. A. Johnston, to be datolite.

Mr. R. L. Broadbent has since visited the mine in question and collected a fine series of specimens which not only fully illustrate its mode of occurrence, but likewise its various mineral associations. On transferring these specimens to me, Mr. Broadbent drew my attention to some small white, occasionally colorless, octahedral crystals which he had observed on some of them. These crystals, more fully referred to further on, were also examined by Mr. Johnston, and identified by him as the somewhat rare mineral, faujasite, a species not previously recognized as occurring in Canada.

The datolite occurs in the form of hard, compact, irregularly shaped, at times more or less nodular, masses some of which are of quite small dimensions, while others are of considerable size—one having been found which measures six inches across and weighs thirteen pounds. It has also occasionally been met with in the form of moist, plastic masses, which on exposure to the air become crumbly and ultimately fall to pieces, forming a loose earth. The masses in question occur imbedded in a matrix composed of an association of a light to somewhat dark greenish-gray, more or less weathered, pyroxene, brown phlogopite, light grayish to white cleavable calcite, grayish-white translucent to colorless transparent quartz, and bluish-green, more rarely faint purplish, yellowish and colorless fluorite, with some intermingled pyrite and pyrrhotite, and small quantities of barite, chabazite and faujasite.

The mineral is greenish-white to all but white in color; is almost opaque; has a dull luster; is brittle; breaks with an uneven to subconchoidal fracture—the fractured surface resembling that of fine stone-ware (Wedgewood-ware). It has a hardness of 5, and a specific gravity, at 15·5° C., of 2·985. Before the blowpipe, it fuses, with slight intumescence, at about 2 to a clear glass, simultaneously coloring the flame

yellowish-green. In fine powder, it is easily and completely decomposed by hydrochloric acid, with separation of gelatinous silica.

The mean of two very closely concordant analyses, conducted by Mr. Johnston, showed it to have the following composition:

Silica	36·94
Boron trioxide	22·37
Lime	34·90
Alumina	0·12
Ferric oxide	0·02
Magnesia	0·05
Water (direct estimation)	5·68
	100·08

2. *Faujasite.*

This species, which has been briefly alluded to in the preceding note as being one of the mineral associations of the datolite, found at the Daisy mica mine, on lot nine of the first range of the township of Derry, Ottawa County, in the Province of Quebec, is there met with in the form of simple octahedral crystals implanted upon the walls of small cavities in the quartz or intimately associated with the fluorite (in some instances being, indeed, included in crystals of the latter mineral), both of which enter largely into the composition of the matrix of the datolite. The crystals vary in size from such as are of almost microscopic minuteness to others having a diameter of about two millimeters. They are mostly milk-white—with, in some instances, a faint greenish tinge, in color, and opaque, occasionally, however, colorless and translucent, and have a vitreous luster. In the closed tube the mineral yields much water. Before the blowpipe, it intumesces and fuses to a white blebby enamel. It is decomposed by hydrochloric acid without gelatinization. An analysis of the same has been entered upon.

ART. XLVIII.—*The Estimation of Molybdic Acid reduced by Hydriodic Acid;* by F. A. GOOCH and O. S. PULMAN, JR.

[Contributions from the Kent Chemical Laboratory of Yale University—CIV.]

WHILE the determination of molybdic acid by estimating the iodine set free upon boiling a solution of that acid in hydrochloric acid to which potassium iodide has been added, is a possibility, the operation is beset with difficulties. If due attention be paid to the proportion of acid, the excess of potassium iodide over the amount theoretically necessary to produce the ideal reduction, and the final degree of concentration of the liquid, the change of the molybdic acid to the condition of oxidation of the pentoxide, Mo_2O_5, may, as has been shown in former articles from this laboratory,* be closely realized. Even when the conditions essential to the ideal reduction obtain, however, the possibility of the interaction of atmospheric oxygen with the hydriodic acid produced from the potassium iodide and hydrochloric acid must be guarded against by conducting the operation in an atmosphere of carbon dioxide. Furthermore, the hydrochloric acid employed must be freed, so far as may be, from dissolved oxygen by previous boiling. The operation is capable of yielding accurate indications (unless by a chance combination of opposite errors) only when the precautions mentioned are scrupulously observed.

On the other hand, the essential principles of the reaction admit of very simple application when the residue of the distillation, instead of the iodine distilled, is made the object of the analytical determination. This was the plan of a method formerly proposed.† In this process the mixture of molybdic acid, potassium iodide and hydrochloric acid was boiled between defined limits of volume in an Erlenmeyer flask simply trapped to prevent mechanical loss during the boiling, and the residue, after the removal of all free iodine, was treated with tartaric acid to prevent subsequent precipitation, neutralized with an alkaline bicarbonate, and reoxidized by a measured excess of standard iodine, this excess of iodine being finally determined by titration with a standard arsenite. The difference between the iodine value of the arsenite used and the amount of standard iodine employed measures the molybdic acid. The action of atmospheric or dissolved oxygen obviously plays no important part in the operation providing all uncombined iodine, however produced, is finally boiled out. At the outset iodine is liberated by the air present as well by the intended action of the molybdic acid, but as the boiling continues the hydriodic acid diminishes in strength, the iodine is driven from the flask kept filled with steam, and if the conditions of the operation have been properly adjusted the molyb-

* Gooch and Fairbanks, this Journal, ii, 156; Gooch and Norton, this Journal, vi, 168.

† Gooch and Fairbanks, this Journal, ii, 160.

dic acid undergoes the ideal reduction. When this point is reached dilution with cold water obviates danger of immediate oxidation and gives opportunity for continuing the treatment referred to above. The method yields accurate results, but is tedious on account of the delay of an hour and a half to two hours before the excess of the iodine introduced to reoxidize the molybdic acid can be safely titrated by the arsenite. Taking the matter up again at this point, we find that it is perfectly feasible to obviate the difficulty in question and to secure immediate reoxidation of the molybdic acid by substituting potassium permanganate for iodine as the oxidizer.

When an excess of potassium permanganate is added to a solution containing hydrochloric and hydriodic acids with molydenum in a condition of oxidation corresponding to the pentoxide, several different effects of oxidation may be expected. There is the immediate liberation of iodine from the hydriodic acid, the production of iodic acid, some slight tendency to liberate chlorine from the hydrochloric acid, the formation of representatives of the higher oxides of manganese, and, lastly the reproduction of the molybdic acid, which is the object of the operation. All other effects than the last must be prevented or recorded in order that the estimation of the molybdic acid may be accomplished. Of the secondary actions, the liberation of chlorine may be prevented by adding a manganous salt, according to the well-known proposals of Kessler* and Zimmerman,† the iodine set free may be converted to hydriodic acid again by the introduction into the acid solution of a sufficient excess of a standard arsenite solution; the iodic acid may be reduced in the acid solution in the same manner, as we have found by experiment, the value obtained for a solution of iodic acid by adding to it in presence of sulphuric acid a measured amount of standard arsenite, making alkaline, and titrating back with iodine, being the same as that found by acting directly upon the iodic acid with an excess of potassium iodide in presence of dilute sulphuric acid and determining by standard arsenite the iodine liberated; and the higher oxides of manganese are likewise reduced in the acid solution by the arsenious acid of the standard arsenite.

Whatever excess of arsenious acid is left over after the reactions described may, obviously, be determined by neutralizing the solution with an alkaline bicarbonate and titrating with iodine.

Every difficulty introduced by the secondary oxidations should, it might be supposed, be overcome by adopting the following procedure: the addition of manganous sulphate to the reduced, diluted, and cooled solution; the introduction of measured standard potassium permanganate until its char-

* Ann. Phys., cxviii, 48; cxix, 225–226. † Ann. Chem. (Liebig), ccxiii, 302.

acteristic color is evident; the treatment of the solution with a measured amount of standard arsenite in known excess; the neutralization of free acid by potassium bicarbonate, first taking pains to introduce, after the destruction of the permanganate by the arsenite, tartaric acid to prevent precipitation of the molbydenum compound; and the titration of the excess of arsenite by iodine.

The operation requires the use of a standard solution of arsenite, easily made with accuracy, a solution of iodine in potassium iodide standardized directly against the arsenite in the usual manner, and a solution of potassium permanganate the value of which in terms of the arsenite is found by

1

2

bleaching a measured portion of it with an excess of arsenite and titrating back with iodine the arsenite remaining. The preparation and adjustment of the standard solutions is therefore simple. The theory of the operation is plain, the value (in terms of molybdic acid) of the permanganate used, diminished by that of the arsenite and increased by that of the iodine, giving the amount of molybdic acid present.

In carrying out our tests of the method proposed we used a preparation of ammonium molybdate made by recrystalizing the presumably pure salt. The constitution of this salt was determined by careful ignition, both by itself and with sodium tungstate free from carbonate. It held 81·83 per cent. of MoO_3.

From 0·3 grm. to 0·5 grm. of the molybdate, at least 20^{cm^3} of hydrochloric acid of sp. gr. 1·20, with from 0·2 grm. to 0·6 grm. of potassium iodide, according to the amount of molybdate used, were put into a 150^{cm^3} flask, trapped loosely by means of a short bulbed tube hung in the neck, as shown in figure 1. The solution was boiled until the original volume of 40 to 60^{cm^3} had been reduced to exactly 25^{cm^3} as determined by a mark upon the flask, the base of which was of a size permitting close reading of the volume of the liquid. The residue was diluted immediately to a volume of 125^{cm^3} and thus cooled, transferred to a Drexel wash-bottle, shown in figure 2, fitted with a ground glass stopper carrying the usual inlet and outlet tubes. To the inlet tube had been sealed a

separating-funnel to serve for the gradual introduction of reagents, and to the outlet tube a Will and Varrentrapp bulbed tube charged with a solution of potassium iodide to catch any traces of iodine thrown off mechanically during the process of neutralization to follow. Through the separating funnel were then added 0·5 grm. of manganese sulphate, and from a burette an approximately $\frac{n}{10}$ solution of potassium permanganate of known value until the characteristic color was given to the solution, the amount of permanganate thus added being noted. Then, from a burette, was added enough of a standard arsenite solution to correspond approximately to the value of the permanganate used; experience having shown that this amount of arsenite is sufficient to reduce with readiness in the acid solution the iodic acid, the permanganate, the higher oxides of manganese, and nearly all the free iodine, the remainder of the last being taken up immediately after the subsequent neutralization. The amount of this solution was noted. Next a solution of about 3 grm. of tartaric acid was run in, and the free acid of the solution was neutralized by acid potassium carbonate. This accomplished, the liquid adhering to stopper and tubes was washed off into the bottle, the contents of the trap added, and the residual arsenite was titrated by standard iodine, using the starch indicator.

The results of experiments are given in the following table:

Weight of MoO_3 taken as ammonium molybdate.	Weight of KI used	Weight of MoO_3 found.	Error.
grm.	grm.	grm.	grm.
0·0423	0·2	0·0430	0·0007 +
0·0429	0·2	0·0435	0·0006 +
0·0420	0·2	0·0427	0·0007 +
0·0827	0·3	0·0829	0·0002 +
0·0837	0·35	0·0838	0·0001 +
0·0826	0·5	0·0832	0·0006 +
0·2465	0·6	0·2460	0·0005 —
0·2481	0·6	0·2469	0.0012 —
0·2470	0·6	0·2465	0·0005 —

It is plain that molybdic acid may be determined with accuracy by reduction under the prescribed conditions with potassium iodide and hydrochloric acid, treatment of the residue with manganous sulphate, standard potassium permanganate, standard arsenic, and, after addition of tartaric acid and neutralization, titration with iodine. When many determinations are to be made the process will yield results with rapidity, because as many operations can be started successively in the Erlenmeyer flasks as an operator can handle with convenience, a simple neutralization bottle serving for the treatment of all the reduced residues as they come along.

ART. XLIX.—*The Veramin Meteorite;* by HENRY A. WARD.

THIS most interesting Oriental meteorite, which fell in northern Persia in 1880, was first made known in Europe by Fred. Dietsch, a German mining engineer, who gave a short account of it on page 100 of vol. xl of the Berg and Hüttenmännische Zeitung, March 18, 1881. His notice was based upon information given him personally by the Shah, who handed him, in confirmation of his words, a fragment of the stone weighing 400 grams. Subsequently Baron Emil Gödel-Lannoy, secretary of the Austrian legation of Teheran, brought two small pieces of the stone to Vienna. One piece, weighing 28 grams, he presented to Baron von Braun; the other, weighing 28 grams, he gave to his friend Dr. Aristid Brezina, who incorporated it in the great meteorite and mineral collection of the Royal Museum, of which collection he was then the director. Brezina described this in a paper before the K. Akademie der Wissenschaften in July, 1881, giving in few words the mineral composition of the fragment with its petrographical characters; but the material was too scanty for a full analysis, and nothing was known about the main mass beyond the fact inexactly reported, that its weight was 45 kilograms, and that it was preserved in the palace of the Shah. So matters remained with Veramin—thus the stone had been called—until the autumn of 1898. At that time I was in Stockholm, where I saw a small fragment of the stone in the hands of Baron Nordenskiöld, who informed me that it had been brought to him from Teheran by a returned Swedish servant (barber) of the Shah. As I had long projected a visit to Persia, and as Veramin had come to have strong attractions for me, I decided that I would at once undertake the long trip. A week later, at St. Petersburg, I obtained through the good offices of our legation an introduction to the Persian ambassador in that capital. That gentleman, Gen. Mirzah Riza Khan, interested himself in my intentions, and gave me several letters to officers of the Shah's court, among them one to Muskah-es-Sultanneh, the Grand Vizier. After first crossing Russia and the Caucasus range to Tiflis in the Transcaucasus, and eastward to Baku on the Caspian, I took steamer down that sea to Enzeli, the port of northern Persia; thence eight days of horseback and two of carriage brought me to Teheran.

After a few days in this city I obtained audience with the Grand Vizier at his private palace. He spoke and understood French, so I told him in simple, unvarnished words the object

of my visit to his country. I had heard in far-distant America of a famous stone which had fallen from heaven many years ago, and was now in the palace of the Shah. That I wished to see it, to examine, weigh and photograph it; and also, if possible, to obtain a piece of it for my collection of these wonderful objects. His excellency informed me that it would be possible to bring about most of my requests as stated, but that he doubted very much my being able to obtain a fragment, even ever so small, of the precious and somewhat celebrated stone. He would, however, at an early day be called to see his Majesty the Shah, and he would then bring up the subject, and ascertain what might be done. In fact, after a few days' delay I received a letter from the Grand Vizier, enclosing word from the Shah inviting him to call on the following day with me and with the American Ambassador, Mr. Arthur Hardy, who had interested himself actively on my behalf. We went promptly the next day. We were joined at the grand outer stairway by the Guardian of the Palace and one or two court attendants, and with them we proceeded at once to the hall of the Peacock Throne, where the audience was to be given. At the further end of the hall, and immediately in front of the throne stood his Imperial Majesty, the Shah, Mozuffer-el-Din (Victorious of the Faith), whom it is proper on such occasions to address as "King of Kings" or "Asylum of the Universe."

I must not dwell upon this interview, interesting as it was in many ways.

The conversation turned chiefly upon meteorites. His Majesty was curious to know more or less about their place of origin, the places in which they had fallen, their general composition, and particularly if any of them contained silver or gold. One point in my conversation with the Shah particularly interested me: This was when, turning to the Guardian of the Palace, who stood at his right, he made some remark illustrated by the fingers of one hand crossing the other, at which the Grand Vizier, interpreting to me, said: "His Majesty says that you may have a piece of the meteorite." This declaration having been made, and I having duly given my thanks, the audience ended.

On our way down the long hall we had our first view of the famous meteorite, which was on a low stand under a window. By its side was a large cardboard label which gave in beautiful Persian characters the short and only preserved account of the fall. I here give the translation, which was kindly made for me by our American Consul, Mr. Edward Tyler.

Translation.

On the 8th of Jamadi-ul-aval A. H. 1298,* at a place called Boogin, the winter quarters of the tribe of Bagadi Shahsevan, about three hours before sunset, there appeared in a clear sky, between Boogin and Eshtahard, a small cloud, followed immediately by an appalling noise. The people were greatly moved, and rushed to their tent doors. While standing there in expectation, they heard nine more terrific explosions, like to the reports of a cannon. Following upon these, something resembling smoke proceeded from the cloud, clearly visible to all the people, descended to the earth and buried itself about seven feet in the ground. A shepherd near the place noticed the exact spot, and with fear and trembling pointed it out to the people. Some of them went and turned up the ground and took out the stone. Hadayat ullah khan, Kajar, the son of the late Eesa Khan Beglerbegee, Governor of the tribe, took possession of the stone, and reported the occurrence to Teheran and sent the stone there.

It will be seen that this label gives the locality of the fall of the meteorite as Boogin. But as no map which I have consulted shows any of these places here mentioned, and as the Palace people called it Veramin, the same name by which Dietsch noted the stone a few months after it fell, it seems proper that his name should be retained. Veramin is a small plain in the District of Karand some fifteen miles eastward of Teheran.

As we descended the staircase, the Guardian of the Palace informed me that his Majesty would soon go to the mountains for a week's hunting, and that then would be a proper time for me to come to the Palace to carry out my work. Accordingly, after two days I returned with a German photographer, whose services I had engaged, and a Persian servant bearing a huge pair of scales, which I had borrowed at the hotel. We put the meteorite on the scales and found that its weight was just 113½ pounds (about 51⅔ kilograms). The stone was shaped like an oblong loaf, about 16 inches in greatest length, 12 inches wide, and with a varying thickness of 7 to 8 inches. The weight of the mass seemed quite inconsistent with the fact that it seemed exteriorly to be largely stone. Its corners were much rounded, and its surfaces covered with characteristic deep pittings. The largest of these pittings was one inch across and half an inch deep; most of the others about one-half these dimensions. About three-fourths of the surface was

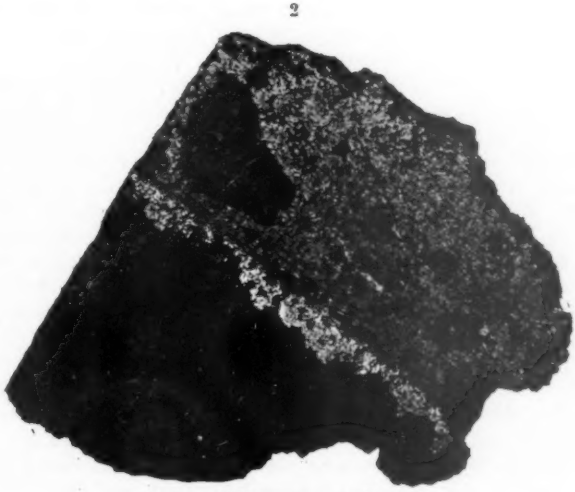
* Although I have sought among members of the Persian Legation in several European capitals, I have been quite unable to ascertain the exact equivalent in our (Christian) Calendar of the Persian date given above. All seem to agree on the month of May, 1880, but hesitate to fix the *day*.—H. A. W.

thus covered; while interspersed were patches with the peculiar tiny vaceolar "goose skin" depressions often seen on the outer rind of iron meteorites, where they seem to be a phenomenon of the cooling of the crust. The lower side of the mass is more irregular and rough, with apparently little crust, but it has a thin coat of mud still adhering to it, acquired doubtless while it lay for several days by a tank in the Palace yard. A fine, thread-like black line, faintly distinguishable,

Veramin. About $\frac{1}{8}$ nat. size.

passes obliquely across the face, and is clearly a line of flowing. This is 12½ inches long, and it, with several shorter lines of coinciding direction, shows clearly the direction of the stone in its passage through the air. Certain small areas of the mass are veneered by a flake of thin iron. Some of these appear to enter the mass as thin plates. The crust or rind of the meteorite is of a dull grayish brown color, and is excessively thin, a mere varnish. Through this rind project countless little points of metallic iron, making little burrs or sharp protuberances on the surface, which have often been flattened or blunted. The surface shows also a few little buttons, barely 2^{mm} across, of black, shining iron oxide; with one or more nodules, from 5 to 10^{mm} in diameter, of crystalline honey-yellow olivine. The ends of the stone have been much abraded by

blows given in an effort to break off fragments. The general appearance of these broken parts is a dull, coarse-grained base or cement, with some larger, crystallized, angular grains imbedded. These broken surfaces are very rough and prickly to the touch, and the glass showed sharp points and granules of white iron intimately sprinkled in with a filling of oily green, glassy olivine. M. Tholazan in 1884* described the inner constituents of the stone, giving them as "bronzite"; a green, infusible and almost insoluble silicate, probably peck-



Section of Veramin. ⅔ nat. size.

hamite; and granules of nickel iron;—all cemented by a fine network of nickel iron. Merrill, after examining a small fragment sent by me to him at Washington, writes me: "I make out the presence of enstatite, olivine; a colorless (in the section) mineral giving an inclined extinction as high as 29° which may be peckhamite: and in addition granules of clear, colorless feldspars, showing distinctly twin striæ, and giving an extinction-angle of 30°. This indicates a basic member of the albite-anorthite series, perhaps bytownite or it may be anorthite."

The polished section of the mass, as seen in the enclosed cut, has a very close resemblance to the Miney meteorite from Taney Co., Missouri. There is the same compact base of the fine-grained elements, both stony and metallic, with segregated patches of each of them in which the matrix is at once more homogeneous and of coarser structure. Besides the myriad

* Comptes Rendus, Paris Acad, vol. xcviii, p. 1465.

granular particles of bright nickel iron, there are occasional nodules of the same element of larger size. One of these which I separated from the mass is a perfect sphere, 8^{mm} in diameter, which lay almost free from attachment except that upon one side it is incrusted by a portion of the firm base mass. A section of this shows it to be a solid metal, which, when a polished surface is etched, gives clearly sharp Widmannstäten figures of a clear pattern. Meunier classes Veramin as a member of his type of Logronite, including with it Barea, Sierra de Chaco, Janecera, Estherville, Miney and Hainholz. Of these seven, but two, Estherville and Veramin, have any crust.

Of about twenty-five siderolites now known to science, only four of them have been *seen to fall.* Veramin has an additional interest as being one of these four. The other three are Barea (Spain) 1842, Lodran (India) 1868, and Estherville (Iowa) 1879. It may not be irrelevant here to call attention to the interesting fact that the siderolites, with their special composition and structure, have been as widely distributed both in time of fall and in geographical dispersion on our globe as have either of the other two—alike artificial—groups of meteorites: the siderites and the aerolites. This seems to attest to each group representing a class of rocks, or mineral aggregations, existing abundantly in some of the asteroids or fragmentary bodies circling in the celestial spaces.

In closing, I return to the narrative portion of my paper to notice the extreme difficulty which I had in breaking the Veramin, due to the very intimate mingling of its stony and its metallic parts. Had the mass been a siderite, I might have cut it with my steel saw, or had it been an aerolite I might have broken off a piece with a hammer; but the intimate mingling of its stony and its metallic parts made a compound so tough that separation seemed quite impossible. After working over the mass, which I had taken to the Palace yard, for several hours, and assisted by a native smith with a large, long-handled hammer, we had failed to detach more than a few ounces of the precious material. It then occurred to us that we should take the meteorite to the arsenal and there undertake to cut it by machinery. The fortunate presence there of an old steam planing machine was in our favor. Steam power, however, there was none. In its absence we harnessed ten or twelve men by ropes at either end of the planer. Yet so hard and refractory was the mass that the work of cutting off a piece barely six inches in greatest diameter required two nights and one day. Then I took my piece and hastened back to Europe. This fine mass of this very rarest of siderolites forms one of the choice specimens in the Ward-Coonley collection of

meteorites now on display (on deposit) in the Geological Hall of the American Museum of Natural History in New York.

As to the composition of Veramin I give here the results of a careful analysis made for me by Prof. J. Edward Whitfield of Philadelphia.

The specific gravity of the stone as received was 4·57.

On separation the stone was found to be made up of 42·3 per cent mineral and 57·7 per cent metal, although the portion separated as mineral contains some iron oxide, which originally must have been metal. Of the metallic portion the specific gravity is 5·56, rather a low figure for metal of this composition.

It was extremely difficult to entirely separate the mineral matter from the metal; although the small particles were hammered until about the thickness of tissue paper, there was an amount of insoluble remaining with it amounting to 9·28 per cent, this of course including any silicon of the metal as silica.

The analysis of the metallic portion, excluding all the insoluble as mineral matter, is as follows:

Iron	92·06	per cent
Nickel	6·96	"
Cobalt	0·73	"
Phosphorus	0·10	"
Sulphur	0·15	"

It was impossible to obtain even a trace of carbon with the small amount of material at hand, and whether or not the metal contains silicon, I cannot say on account of the difficulty of obtaining the metal free from mineral matter. The analysis was made on an amount approximating four grams, any other determinations being impossible for want of material.

J. E. W.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *Double Compounds of Antimony Pentachloride, etc.*—Rosenheim and Stellmann have obtained a pyridine-antimonic double chloride having the formula $3C_5H_5NHCl{\cdot}SbCl_5$, and also analogous quinoline and dimethylaniline double salts. These compounds are interesting, inasmuch as very few double halides of quinquivalent elements are known. These chemists have prepared also a pyridine-antimonic double bromide, $2C_5H_5NHBr{\cdot}SbBr_5$, which shows for the first time the existence of antimony pentabromide, and they believe that they have isolated the uncombined pentabromide. They have succeeded in preparing also a remarkable series of compounds of antimonic chloride with organic compounds containing oxygen. Such compounds with alcohols and ether were described by Williams many years ago, but the present list shows that antimonic chloride is capable of combining with many classes of compounds. It forms with acetaldehyde $SbCl_5{\cdot}CH_3CHO$; with benzaldehyde $SbCl_5{\cdot}C_6H_5CHO$; with acetone $SbCl_5{\cdot}(CH_3)_2CO$; with ethyl benzoate $SbCl_5{\cdot}C_6H_5COOC_2H_5$; with benzoyl chloride $2SbCl_5{\cdot}3C_6H_5COCl$; with acetamide $2SbCl_5{\cdot}3CH_3CONH_2$; with phthallic anhydride $2SbCl_5{\cdot}3C_6H_4C_2O_3$; with succinic acid $2SbCl_5{\cdot}C_2H_4(COOH)_2$.—*Berichte*, xxxiv, 3377. H. L. W.

2. *The Thermochemistry of Alloys.*—In order to determine the heat of combination of a series of copper-zinc alloys, T. J. Baker has dissolved the finely-divided alloys in a calorimeter by means of solutions of ferric chloride and of cupric chloride. Both of these solutions contained ammonium chloride; they dissolved the metals rapidly without evolution of gas, and the two solutions gave closely agreeing results. The amounts of heat produced by dissolving the alloys were then compared with results obtained by dissolving mixtures of the uncombined, powdered metals, and in every case the alloy gave a smaller amount of heat, the deficiency expressing the heat of combination of the two metals. It was found that the heat of solution of 1 gram of pure copper was 179 cal., while the corresponding value for zinc was 927 cal. When mixtures of the two metals were taken, results were obtained which corresponded to those calculated from the above values. In the alloys the greatest heat of combination, amounting to 52·5 cal. per gram, was found to occur where 32 per cent of copper was present. This corresponds to the formula $CuZn_2$ and indicates the existence of a compound of this composition.—*Zeitschr. physikal. Chem.*, xxxviii, 630. H. L. W.

3. *Acid Nitrates.*—More than twenty years ago an acid potassium nitrate and two acid ammonium nitrates were described by Ditte. These salts attracted little attention, probably because they were formed at low temperatures and were very unstable, and the opinion seems to have prevailed up to the present time

that nitric acid, being monobasic, is incapable of forming acid salts. WELLS and METZGER have recently found that rubidium and cæsium each form two acid nitrates which are comparatively stable, and they have also prepared an acid thallous nitrate. Ditte had made the thallous salt and one of the rubidium salts, but he did not use the proper method for obtaining them in a pure condition, and consequently did not ascertain their true compositions. The recent additions and revisions give the following list of acid nitrates:

$KNO_3 \cdot 2HNO_3$	
$NH_4NO_3 \cdot 2HNO_3$	$NH_4NO_3 \cdot HNO_3$
$RbNO_3 \cdot 2HNO_3$	$RbNO_3 \cdot HNO_3$
$CsNO_3 \cdot 2HNO_3$	$CsNO_3 \cdot HNO_3$
$TlNO_3 \cdot 2HNO_3$	

The cæsium and rubidium salts form large colorless crystals which, although somewhat unstable, may be readily handled at ordinary temperatures; in fact, $CsNO_3 \cdot HNO_3$ is so stable that it shows a sharp melting-point at 100°. The potassium, ammonium and thallium acid nitrates have low melting-points, varying from −3 to 18°, so that they require low temperatures for their formation. The diacid salts are produced by dissolving the normal nitrates in nitric acid of 1·50 sp. gr. and cooling to crystallization, while the monacid salts are similarly prepared from acid of 1·42 sp. gr.—*Amer. Chem. Jour.*, xxvi, 271. H. L. W.

4. *Methods of Standardizing Acid Solutions.* — CYRIL G. HOPKINS has compared six different methods of standardizing volumetric acid solutions. He finds that the determination of chlorine in hydrochloric acid by weighing silver chloride in a Gooch crucible gives more closely agreeing results than the other methods that he has tried, while neutralizing sulphuric acid with ammonia, evaporizing to dryness, heating the residual ammonium sulphate to 120°, and weighing it (Wenig's method) also gives very satisfactory agreements. The method of Hart and Croasdale, which consists in eleetrolyzing copper sulphate, weighing the precipitated copper, and using the liberated sulphuric acid as the basis, gave rather poorly agreeing results. Hartly's method of standardizing with metallic sodium was found to be unreliable, apparently on account of impurities in the sodium. Rimbach's method, by use of crystallized borax with methyl-orange as an indicator, was found to be unsatisfactory, because the borax gradually lost water of crystallization in the air. This is contrary to Rimbach's experience, and is probably due to a difference in atmospheric conditions. The method of standardizing oxalic acid by means of potassium permanganate solution, the latter being compared with metallic iron, is stated to give fairly good results. It would be interesting if the author had included several other methods in his comparison; for instance, Grögger's method, which is based on the liberation of iodine by the action of an acid upon potassium iodate and iodide, and also the very

widely used sodium carbonate method.—*Jour. Amer. Chem. Soc.*, xxxiii, 727. H. L. W.

5. *New Element Associated with Thorium.*—By treating an ordinary thorium chloride solution with sulphurous acid and boiling, CHARLES BASKERVILLE has found that a precipitate is produced which gives an oxide of lower specific gravity than a part of the earth not precipitated by this means. By other processes of fractionation he has obtained similar results, and he believes that the heavier oxide contains a new element for which he proposes the name Carolinium with the symbol Cn. It is to be hoped that at last a well-characterized new element is to be described in this country, but we must wait for further details before deciding whether this is a new element or a mixture of old ones.—*Jour. Amer. Chem. Soc.*, xxiii, 761. H. L. W.

6. *A Laboratory Guide to the Study of Qualitative Analysis*, by E. H. S. BAILEY and HAMILTON P. CADY. 8vo, pp. 234. Philadelphia, 1901 (P. Blakiston's Son & Co.).—The importance of teaching the ionic theory to some extent in connection with the facts observed in the study of qualitative analysis is now widely recognized. The book under consideration begins by giving in an introduction an elaborate explanation of electrolytic dissociation and the mass law. If a student could understand this introduction, he would be far beyond the need of a course in qualitative analysis; for here are introduced the equilibrium of "phases" and many quantitative conceptions, including a mathematical treatment of the mass law, which it would be better to present to the student after an extensive course in both qualitative and quantitative analysis, rather than as an introduction to the first of these subjects. The ionic idea is carried to the utmost limit throughout the book, and the language would appear like mere jargon to those who are not versed in the modern theories of solutions. For instance, the usual test for phosphoric acid is described as follows: "The orthophosphate ion forms with the molybdate ion, MoO_4^{--}, from ammonium molybdate, in nitric acid solution, a phosphomolybdate ion, which combines with the ammonium ions present to form a canary-yellow precipitate of ammonium phosphomolybdate. . . . This precipitate dissolves in ammonium hydroxide because under these conditions the phosphomolybdate ion is changed to the molybdates and orthophosphate ions." (No formula is given either for the phosphomolybdate ion or the yellow salt.) It may be mentioned that the unsightly spelling of certain chemical words, such as "iodin," "sulfid," and "hydroxid," is used in this book. The number of pages gives a wrong idea of the size of the work, for half the pages left blank for notes are counted. H. L. W.

7. *The Elements of Qualitative Analysis;* by WM. A. NOYES. 8vo, pp. 101. New York, 1901 (Henry Holt and Co.).—This is the fifth edition of this little book, the first of which appeared in 1887. It is evident from the rapidity with which the editions have appeared that the work is extensively used.

The present issue has been revised and the part dealing with the detection of the acids has been made more systematic. The book contains a concise statement of the ionic theory, with illustrations of its application to qualitative analysis. H. L. W.

8. *Die heterogenen Gleichgewichte vom Standpunkte der Phasenlehre;* von Dr. H. W. Bakhuis Roozeboom. Vol. I, pp. 216, 8vo. Braunschweig. 1901. (Friedrich Vieweg & Sohn.)—The introduction to this volume is devoted to a discussion of the Gibbs' phase rule with a few general applications to cases of equilibrium. Book I deals very systematically and thoroughly with equilibrium in systems containing one component. Volumes II and III are to be devoted to systems of two and three components, respectively.

Roozeboom, in 1887, was the first to apply the phase rule to chemistry and since then he has contributed perhaps more than anyone else to our knowledge of chemical equilibrium. The book can be most heartily recommended as giving a thorough presentation of the subject. H. W. F.

9. *Viscosity of Helium.*—Lord Rayleigh found for the viscosity of pure helium, between 15° and 100°, the value $h = 0{\cdot}681$ and C (Sutherland) = 72·2. H. Schultze, who has also worked on the viscosity of argon, has redetermined the viscosity of helium, but regrets that the helium used by him was not perfectly pure. He, therefore, compares his results with that found by Rayleigh for helium not wholly pure. The latter found in this case $h = 0{\cdot}96$. Schultze finds $h = 1{\cdot}086$ at 15°. He calls attention to a new and unexplained phenomenon in the transpiration of gases. He often found a difference of over 1 per cent in the results of the measurement of the viscosity of a mixture of gases—such as helium and neon or argon—and these differences arose from a change in direction of the transpiration of the gases through the capillary tube. The author does not agree with O. E. Meyer in attributing the phenomenon to the character of the capillary tubes.—*Ann. der Physik*, No. 10, 1901, pp. 302–314. J. T.

10. *Air-tight glass stop-cocks.*—All who have worked in subjects requiring high exhaustions have met with difficulty in obtaining air-tight stop-cocks. The most perfectly ground glass stop-cocks will leak after a few hours. This leaking is hastened by the presence of high tension electrical apparatus, and in this case is apparently due to minute paths formed by electrification on the surface of the stop-cock. Hermann Thiele and Moritz Eckardt describes a mercury seal for a stop-cock which prevents to a high degree the leaking of the cock. They also describe a mercury seal which dispenses with a stop-cock.—*Ann. der Physik.*, No. 10, 1901, pp. 428–431. J. T.

11. *Migration of the ions.*—Hittorf has shown the dependence of this migration upon the concentration and the temperature of the solution of the electrolyte. R. Gans investigates the dependence of this migration upon physical conditions and finds

that the relative change in the velocities u and v of the ions follows in the same sense and amount the changes in the pressure. From the change in conductibility and the number denoting the amount of migration, one can calculate the change in the velocity of the ions.—*Ann. der Physik.*, No. 10, 1901, pp. 315–330.

J. T.

12. *Photometry of the Ultra-Violet rays.*—The great intensity of the light electric effects produced by an electric spark, leads H. KREUSLER to experiment with a view to determining whether the phenomenon might not lead to a method in photometry. The electrodes for the spark consisted of aluminum, zinc, and an alloy of equal parts of zinc and cadmium, with addition of 5 per cent of antimony. No constant light was obtained except in the case of aluminum if both electrodes were of the same metal. This constancy was obtained, however, if the negative pole was made of aluminum. The photo-electric cell was that of Warbury, consisting of suitable electrodes in an atmosphere of rarified hydrogen. The measurements were carried out with the object of determining the absorption coefficients of various gases and of water. Although there were evidences of constant errors the method seems a promising one.—*Ann. der Physik.*, No. 10, 1901, pp. 412–423. J. T.

II. GEOLOGY AND MINERALOGY.

1. *Glaciation in Tierra del Fuego and in the Antarctic.*—In a very interesting account of the Antarctic voyage of the "Belgica" during the years 1897 to 1899, read before the Royal Geographical Society by HENRY ARÇTOWSKI, of the scientific staff of the expedition, some observations are given in regard to the ancient glaciers of Tierra del Fuego, and also of parts of Graham Land and neighboring islands in the Antarctic directly south of Cape Horn. In respect to Tierra del Fuego, the author remarks that well-preserved traces of the former extension of the glaciers were observed at numerous points. The bay of the great glacier is a fine fiord opening into Darwin channel; this fiord is divided into basins by three large transversal moraines. He adds: "The transversal moraines are not the only indications of the ancient extension of the great glacier. They rather mark with great clearness the stages of a rapid retreat of this immense river of ice at the close of the glacial epoch. The sides of the mountains which border the fiord bear *roches moutonnées* at considerable altitudes, and one of the mountains has the characteristic outline of a huge sheep's back surmounted by a small hillock. This latter has sharp ridges, whilst all the rest of the mountain is polished and planed by the erosive action of the ice. I have no doubt that during the glacial epoch it was a nunatak rising above the surface of the inland ice which covered the Darwin mountains, and which certainly reached to this point. It was not merely, therefore, the head of the fiord which was blocked with

ice, but the whole of this immense valley was buried in this outpouring of the inland ice, until only a few of the mountain summits remained above the surface of the icy mantle." Similar observations were made on the neighboring Staten Island.

The author remarks upon the remarkable character of the present Antarctic glaciers in being usually simply ice-caps, forming convex glaciers covered with heavy snow. There are, however, also both ice rivers and cascades, and forms recalling "corrie glaciers" all alike buried beneath a mantle of perpetual snow, and bare ice is nowhere seen. Numerous evidences were observed of the greater extension of glaciers in former times, in the frequent occurrence of *roches moutonnées*, in the moraines and in the distribution of erratic blocks.

Moraines were observed at various points along Belgica strait between Danco Land and the outlying islands. One of these moraines at Cape Reclus, running from northeast to southwest, had a great extent, and it was concluded that the glacier producing this moraine must have had a breadth of 10 miles and a depth of 342 fathoms. Another moraine on Banck island had a height of 65 feet and ran parallel to the strait. There must have been formerly an immense glacier which flowed westward through Belgica strait toward the Pacific ocean. It is suggested that the facts observed indicate that the existing climate of Antarctic lands in 64° south latitude may be to-day much the same as that which prevailed in Tierra del Fuego (54° S. L.) during the ice-age.—*Geogr. J.*, xviii, 353.

2. *The Glaciers of Switzerland in 1900.*—The Sixth Annual Report of the International Commission of Glaciers, edited by S. FINSTERWALDER and E. MURET, gives a summary of the condition of glaciers over the northern hemisphere during the year 1900. In regard to the glaciers of Switzerland, it states that the phase of retreat, characteristic of the years preceding, has still continued. It may be said that in 1900 all the glaciers of Switzerland, with a single exception, were either at a state of minimum or actually receding. The exception is the small glacier of Boveyre in val d'Entremont (Valais), which attained an elongation of 8 meters in 1900, and of 113 meters between 1892 and 1900. Six other glaciers are mentioned as possibly advancing, though the observations need confirmation, but of the remaining seventy-five examined, sixty-one were certainly and fourteen probably retrograding.—*Bibl. Univ.*, xii, 1901.

3. *United States Geological Survey:* CHARLES D. WALCOTT, Director.—Three volumes of the Twenty-first Annual Report have recently been issued. These include Parts I and VI. The former contains the Director's Report already issued in separate form and noticed on page 468 of Vol. XI. With this are included also appendixes, including triangulation, primary traverse and spirit leveling.

Part VI, devoted to the Mineral Resources of the United States for 1899, prepared by David T. Day, is issued in two volumes, of upwards of 600 pages each. The first includes Metallic Products with Coal and Coke; the second Non-Metallic Products. The separate topics are handled as heretofore by different individuals, and a large amount of information is thus put before the public, with great promptness, in regard to the development of the mineral wealth of the country.

4. *Indiana: Department of Geology and Natural Resources.* 25th Annual Report, 1900. W. S. BLATCHLEY, State Geologist.—In addition to the usual annual reports and statistics on oil, gas, coal and building stone, this volume contains articles on Portland Cement, by W. S. Blatchley, and Hydraulic Limestone of Southeastern Indiana, by C. E. Siebenthal. The paper on The Lakes of Northern Indiana and their associated Marl Deposits, by W. S. Blatchley and Geo. H. Ashley (pp. 31–322), takes up the question of the origin of the lakes and of the marl and gives maps and detailed descriptions with analyses of over 100 occurrences. 'The original source of the marl material is the glacial clay and it is brought into the lakes by subaqueous springs and is deposited because of the loss of carbondioxide. This loss is caused either by increase in temperature or decrease in pressure or by the action of aquatic plants.' This conclusion is not in accord with the results obtained by C. A. Davis from a study of the Michigan lakes (Jour. of Geol., Sept.–Oct., 1900, and Sept.–Oct., 1901), in which plants "alone have produced a very large part of the marl." In this volume (pp. 530–758 + 31 plates) Dr. E. M. Kindle publishes his final paper on the Devonian Fossils and Stratigraphy of Indiana. H. E. G.

5. *Geological Survey of New Jersey, Annual Report, 1900.* Trenton.—This report shows progress in all divisions of the state work. One-sixth of the field work for the new topographic map (2000 ft. to the inch) is now done; a new series of geological maps is planned; the study of the Paleozoic formation was continued: much new data was collected on artesian wells, forestry, drainage of swamps, etc. The report includes the following papers: A Preliminary Report on the Palaeozoic Formations, by Stuart Weller (pp. 1–8); Report on Portland Cement Industry, by H. B. Kimmel (pp. 9–101); Artesian Wells, by Lewis Woolman (pp. 103–171); Mineralogical Notes, by Albert H. Chester (pp. 173–188); Chlorine in the Natural Waters of the State, by Wm. S. Myers (pp. 189–196); the Mining Industry, by H. B. Kimmel (pp. 197–213). H. E. G.

6. *Ice Ramparts;* by E. R. BUCKLEY, Ph.D., with a discussion by Professor C. R. Van Hise. Trans. Wis. Acad. of Sciences, Arts and Letters, vol. xiii, pp. 141–162 with 17 plates.—Dr. Buckley has made a study of the behavior of expanding and contracting ice and the resulting deformation of the ice and of the shore. The facts collected are of interest in themselves, but as Professor Van Hise points out, their greatest value lies in the

fact that the phenomena "reproduce on a larger scale than has been possible by experiment in the laboratory, many of the phenomena of crustal deformation." "The analogies are so astonishingly close as to lead to the conclusion that in most cases crustal forces have acted in a similar manner to those in which the forces in the ice have acted." H. E. G.

7. *Syllabus of a Course of Lectures on Elementary Geology;* by JOHN C. BRANNER, Ph.D. Stanford University Press, 1898. Pp. 301. *Syllabus of a Course of Lectures on Economic Geology;* by JOHN C. BRANNER and JOHN F. NEWSOM. Stanford University, 1900. Pp. 346.—These publications are useful additions to a geologist's teaching outfit, and are adapted to the uses of students while in college and afterward. These books may well be recommended to general readers who wish a guide in geological reading. The outlines are full, the illustrations clear and abundant, and the bibliography is well chosen for the purpose in view. H. E. G.

8. *The Loess of Iowa City and Vicinity;* by B. SHIMEK, C.E. Bull. Laboratories of Nat. Hist., University of Iowa, vol. v, No. 2, pp. 195–212.—From a study of the fossil shells found in the loess, Mr. Shimek concludes that "bodies of water did not exist where loess is now found." "The molluscan fauna of the loess points to comparatively dry upland terrestrial conditions such as exist over the greater part of Iowa to-day." H. E. G.

9. *The River System of Connecticut;* by WILLIAM HERBERT HOBBS. Jour. Geol., Sept.–Oct., 1901.—The location of Connecticut rivers is explained by Professor Hobbs as the result of faulting. H. E. G.

10. *The Sivamalai Series of Eleolite-Syenites and Corundum-Syenites in the Coimbatore Distr., Madras Presidency;* by THOS. H. HOLLAND. Mem. Geol. Surv. India, vol. xxx, pt. 3, pp. 169–220, 1901.—Eleolite-syenite forms the main mass of a large hill in the district mentioned. It is gneissoid, having a well-marked foliation, generally in conformity to the enclosing gneisses. There are several varieties of the rock, the most prevalent being an even gray one consisting of 34 per cent eleolite, 56 of microperthite feldspar, 3·6 of magnetite and 6·4 of biotite, plagioclase, graphite, etc. An analysis by T. L. Walker gave

SiO_2	Al_2O_3	Fe_3O_4	MgO	CaO	Na_2O	K_2O	C	Ign.
55·68	23·81	4·84	0·65	1·69	9·23	5·16	0·58	0·34=101·98

The chief point of interest lies in the presence of the graphite, distributed in thin scales. It shows on heating, after treatment with nitric acid, the phenomenon of "sprouting" which has been held by Moissan to be characteristic of graphite crystallized from fusion. Not only is the graphite in the main rock type but also in coarse-grained "contemporaneous veins" and in black basic lenses or dike-like bands.

As the occurrence of graphite as a well-defined constituent of a rock which has been held heretofore to be of purely igneous

origin is a novel phenomenon of great interest, the author has studied with care the field relations of the rock mass. There is, however, no direct evidence to be obtained from the exposures as to its intrusive nature. So far as can be made out, it occurs as lenticular masses in the schists. There are many points, however, to be seen in the field which are characteristic of igneous masses, and balancing all the evidence obtainable the writer feels it to be distinctly in favor of considering the rock masses eruptive in origin. The foliated structure is thought to have been imposed before complete consolidation. Agreeing with this view, we are now forced to recognize graphite as a new and possible constituent of igneous rocks, which may give rise to new types on occasion.

The corundum occurs in a feldspathic rock associated with the eleolite-syenite. Some varieties contain a red garnet, others chrysoberyl. This syenite is found with the eleolite-syenite in such a way that its exact relations cannot be definitely told, but it is held to be a differentiated product of the same magma. There is thus a remarkable analogy with the occurrence in Hastings County, Ontario.* L. V. P.

11. *On a Peculiar Form of altered Peridotite;* by T. H. HOLLAND. Mem. Geol. Surv. India, vol. xxxiv, pt. 1, pp. 1–9, 1901.—The auther describes a rock mass at Huliyar, Mysore State, India, consisting of a matrix of interlaced colorless talc and pale green picrolite (columnar serpentine) with numerous granules of a rhombohedral carbonate and magnetite dust in which lie well-formed, porphyritic crystals of dark gray breunnerite, from one-half to one inch across; they form 35 per cent of the rock. From its staining with iron oxide the rock appears like a diabase with porphyritic pyroxenes or hornblendes. The matrix and breunnerites were analyzed separately, and combining the analyses the rock is found to have the composition

SiO_2	Fe_3O_4	MgO	CO_2	H_2O
27·3	12·7	35·0	20·0	5·0 = 100·0

From this it is assumed that the rock was a dunite which has been changed by the action of water and carbonic acid. L. V. P.

12. *Perknite.*—This name has been proposed by H. W. TURNER for the dark-colored, heavy, basic, holocrystalline igneous rocks composed of monoclinic amphibole or pyroxene or both. In addition to these chief components, rhombic pyroxene, olivine or feldspar may occur as secondary ones and there may be accessory biotite, iron ore, etc. These rocks have hitherto been called pyroxenite or amphibolite or hornblendite, but they have not

* The occurrence of graphite as a well-marked constituent of an igneous rock is a matter of great interest and importance. It will be correlated with the diamonds in the peridotites of South Africa and in certain meteorites and throws new light on its occurrence in pegmatite dikes described from Canada. If it can be definitely shown by sufficient evidence that carbon is a constituent of the deep-seated magmas, certain vexed questions in geology may be susceptible of a better explanation than any yet offered. L. V. P.

been grouped under one name, as here proposed.—*Jour. Geol.*, vol. ix, pp. 507–511, 1901. L. V. P.

13. *Outline of Elementary Lithology;* by GEO. H. BARTON. Pp. 112, 12mo. (Boston, 1900.)—This little work is a digest of the main features of the subject of Lithology. The important rock-making minerals and their properties, the names, textures, and classification of rocks, are given in synoptical form. It will be found useful by students reviewing a lecture course on this subject. L. V. P.

14. *Synchisite and Molybdophyllite.*—A recent number (No. 9) of the Bulletin of the Geological Institution of the University of Upsala contains a mineralogical paper by G. Flink with notes on several known species and also descriptions of the new species, synchisite and molybdophyllite.

SYNCHISITE, from Nararsuk in southern Greenland, was earlier described by G. Nordenskiöld as parisite. It is now found, however, to be distinct. The crystallization is rhombohedral instead of hexagonal and it shows no distinct cleavage. Crystals have commonly the form of acute rhombohedrons. The hardness is 4·5; specific gravity 3·902; color wax-yellow. The composition $CeFCaC_2O_6$ is deduced from analyses, the most recent of which (by Mauzelius) is as follows:

CO_2	ThO_2	Ce_2O_3	$(LaDi)_2O_2$	Y_2O_3	Fe_2O_3	CaO	F	H_2O
25·99	0·30	21·98	28·67	1·18	0·11	16·63	5·04	2·10=102·00

MOLYBDOPHYLLITE is a new lead silicate from Långban, Sweden. It occurs in irregular foliated masses, resembling mica, imbedded in granular limestone; crystallization hexagonal; cleavage basal perfect. The hardness is 3 to 4; specific gravity 4·717. It is colorless with pearly luster on the cleavage face, elsewhere glassy. The composition $R_2SiO_4+H_2O$ is given by the analysis:

SiO_2	PbO	MgO	Al_2O_3	Na_2O	K_2O	H_2O
18·15	61·09	11·71	0·46	0·82	0·69	6·32=99·24

15. *Crystallization of Stannite.*—L. J. SPENCER shows that stannite crystallizes not in the tetrahedral group of the isometric system as has been assumed, but in the scalenohedral group of the tetragonal system, as early suggested by Haidinger. Crystals from Bolivia are very near chalcopyrite in occurring forms and in angles, and like it are often pseudo-cubic from twinning.—*Min. Mag.*, xiii, 54.

16. *Conchite and Ktypteite.*—H. VATER shows that the supposed new form of calcium carbonate, called conchite (p. 84) by Agnes Kelly, is in fact not distinct from aragonite. The ktypteite of Lacroix is probably also identical with the same mineral.—*Zeitschr. f. Kryst.*, xxxv, 149.

17. *The Meteorite of Felix, Perry County, Alabama.*—An account has recently been given by G. P. MERRILL of the stony meteorite which fell near Felix, Alabama, on May 15, 1900.

The explosion of the original meteor yielded three pieces; of these, the main mass recovered weighed about 7 pounds; a second small piece was found but lost and a third has not been found. The material of the meteorite is soft and friable, resembling somewhat the stones of Warrenton, Missouri, and Lancé, France, though darker than the former and more chondritic than the latter. It consists essentially of the minerals olivine, augite, and enstatite, with troilite and native iron, the silicates occurring in the form of chondrules, or associated more or less fragmental particles, embedded in a dark, opaque, or faintly translucent base, which is irresolvable so far as the microscope is concerned. The non-metallic portion (including troilite and chromite) made up 97 per cent of the whole and nickeliferous iron only 3 per cent. The dark color of the stone is attributed to carbon distributed as minute flakes of graphite.—*Proc. U. S. Nat. Museum*, xxiv, 192.

III. Zoology.

1. *Note on the Nomenclature of Bermuda Birds.*—Mr. A. Hyatt Verrill published a short paper on the Bermuda avifauna in this Journal for July, 1901 (issued the last of June). He also printed a more detailed article in "The Osprey," v, pp. 83–85, for June, 1901, with figures of the three following species and of the Tropic Bird, photographed from life. In these articles he described the Bermuda Cardinal Bird and the Blue Bird as new sub-species, peculiar to Bermuda. The Cardinal Bird he named *Cardinalis cardinalis Somersii;* the Blue Bird, *Sialia sialis Bermudensis;* the Ground Dove, *Columbigallina passerina Bahamensis.*

Outram Bangs and Thos. S. Bradlee also published a paper on the Birds of Bermuda in "The Auk" for July, 1901, pp. 249–257, in which new names are given to two of these birds and two others, which they call new species.

They name the Ground Dove, *Columbigallina bermudiana;* the White-eyed Vireo, *Vireo bermudianus;* the Catbird, *Galeoscoptes bermudianus;* the Cardinal, *Cardinalis bermudianus.* Mr. Verrill's article in this Journal appears to have been published a few days earlier than the latter.

To me it seems quite useless to regard these very slightly differentiated forms as distinct "species." The differences noted in the Ground Dove, Catbird, and Vireo, are trivial and scarcely sufficient to constitute *varieties.* To consider them as "sub-species" is certainly a sufficient strain on the much-stretched meaning of the term "sub-species." I should at most call these mere local varieties, scarcely differentiated.

In respect to the Ground Dove, there are reasons for believing that it was introduced to Bermuda from the Bahamas, since the settlement of the islands, like many other things. None of the earlier writers mentioned it in the lists of birds that they gave.

This would hardly have been the case had it been present, for it is exceedingly tame and familiar.

Mr. A. K. Fisher, in Bird Lore, Oct., 1901, p. 178, states that the original *Motacilla sialis* Linné, ed. x, p. 187, was from Bermuda. This is not correct. Linné gave it as from "Bermudis & America calidore." He also quoted Catesby, Hist. Carolina, etc., p. 47, pl. 47, 1731. Catesby says that he had seen it in "Carolina, Virginia, Maryland, and the Bermudas." But he states in his preface that his birds were mostly drawn in Carolina and Georgia, where he spent several years in drawing them. A few were drawn in the Bahamas, where he spent about a year, mostly on the fishes and plants. He does not say that he made *any* drawings in Bermuda, where he probably made a mere passing visit. The Bluebird does not occur in the Bahamas. His figure clearly represents the common North American variety.

A. E. V.

2. *Reports on the Fauna of Porto Rico.*—As a result of the scientific expedition to Porto Rico on the Steamer "Fish Hawk," 1898–99, the United States Fish Commission has published, in its Bulletin for 1900, several valuable reports on the fauna of the island.

The largest and most fully illustrated is the Report on the Fishes and Fisheries, by Everman and Marsh, 1900, (350 pages, 49 colored plates, and a map). In this report 291 species of fishes are included. The plates are excellent. They were drawn and colored from life by A. H. Baldwin and C. B. Hudson. It forms an excellent manual for any part of the West Indian region.

The Report on the Brachyura and Macrura, by Miss M. J. Rathbun (137 pages, 2 colored plates) is also a very complete report on these Crustacea. It contains descriptions of all the genera and species, with analytical tables, and will serve as a standard manual.

The Report on the Anomura, by J. E. Benedict (17 pages, 4 plates) is of the same excellent character.

Mr. R. P. Bigelow has reported on the Stomatopoda (10 pages, with cuts).

Mr. H. F. Moore has prepared the Report on the Isopoda (14 pages, with cuts, and 5 plates), and Mr. M. A. Bigelow, a very short Report on the Cirripedia, which were evidently much neglected.

The Report on the Echinoderms is by Professor H. L. Clark (33 pages, 3 plates). It is fairly complete for the shallow water forms, though many common West Indian starfishes and ophiuroids are lacking.

The Report on the Annelids, by A. L. Treadwell (27 pages, with cuts) contains a considerable number of new species, but is evidently based on a very incomplete collection.

Mr. W. R. Coe has also contributed a short report on the very few nemerteans that were obtained.

J. P. Moore has described two new leeches.

We understand that several other reports, on other groups, are soon to be printed. A. E. V.

3. *Papers from the Alaska Harriman Expedition.*—Several useful and valuable reports on the collections obtained by the Harriman expedition have already been printed by the Washington Academy of Sciences.

The Report on the Nemerteans, by W. R. Coe (March, 1901, 84 pages, with cuts and 13 plates, 6 colored), is, perhaps, the most important and complete of those hitherto published. It relates to a group that is very richly developed on the Alaskan coast, and which has hitherto been almost entirely neglected in those waters. It includes 32 species, of which 28 are new. The colored figures are excellent. A. E. V.

4. *Zoölogy: An Elementary Text Book;* by A. E. Shipley and E. W. MacBride. London and NewYork, 1901 (The Macmillan Co.). 8vo, 632 pages, 347 cuts.—Although called "elementary" this is a rather complete text-book, suitable for the more advanced students in colleges and universities, or for a reference book. The treatment of the subjects is clear and the illustrations are generally excellent. The Vertebrata (or Chordata) occupy an unusually large part (nearly half, or 286 pages) of the book, which will probably be considered an advantage by many instructors. But it compels a severe cutting down of the space for some of the important groups of Invertebrata. Thus the great group of hexapod insects occupies only 23 pages, and the Mollusca 39 pages.

It is an excellent addition to the list of recent text-books and manuals of zoölogy. A. E. V.

5. *An Elementary Course of Practical Zoölogy;* by T. Jeffrey Parker and W. N. Parker. London and New York (The Macmillan Co.). Small 8vo, 608 pages, 156 cuts.—This is intended mainly as a laboratory guide for a course in "biology" or comparative anatomy, such as is commonly given in many of our colleges and scientific schools. For this purpose it seems to be admirably adapted, being more up to date than most of the similar works now in use. About one-third the book (215 pages) is devoted to the study of the frog, in detail. The balance is devoted to various other typical forms, such as the amœba, hydra, earthworm, crayfish, mussel, amphioxus, dogfish, rabbit. About 60 pages, at the end, are devoted to cell structure and embryology.

A. E. V.

IV. Miscellaneous Scientific Intelligence.

1. *National Academy of Sciences.*—The following is a list of the papers entered to be read before the National Academy at the meeting in Philadelphia, held Nov. 12–14.

George F. Becker: Note on linear force exerted by growing crystals. Note on the orogenic theory of tilted blocks.

HORATIO C. WOOD, JR.: On the vaso-motor supply of the lungs.

GEORGE F. BARKER: Biographical memoir of Frederick Augustus Genth. The monatomic gases. The newer forms of incandescent electric lamps.

JAMES M. CRAFTS: On the pseudo-catalytic action of concentrated acids.

SAMUEL L. PENFIELD: On the use of the stereographic projection in making accurate maps; with criticism of some recent methods of map projection. The tendency of complex chemical radicals to control crystallization because of their mass effect; a study in isomorphism.

CHARLES S. PEIRCE: On the logic of research into ancient history.

EDGAR F. SMITH: Observations on tungsten.

S. WEIR MITCHELL and SIMON FLEXNER: Snake venom in relation to hæmolysis, bacteriolysis and toxicity.

IRA REMSEN: On the nature of the double halides.

CYRUS B. COMSTOCK: Biographical memoir of General John Newton.

HENRY F. OSBORN: Dolichocephaly and Brachycephaly as the dominant factors in cranial evolution. Cranial evolution of Titanotherium II. Latent or potential homology.

EDWARD W. MORLEY and CHARLES F. BRUSH: A new gauge for the direct measurement of small pressures. Transmission of heat through vapor of water at small pressures.

CARL BARUS: On quadrant electrometry with a free light needle highly charged through a conductor of ionized air. On nuclear condensation in the vapor of non-electrolytes like benzene; and on graded condensation.

HENRY L. BOWDITCH: The work of the International Association of Academies.

CASWELL GRAVE: A method of rearing marine larvæ.

2. *Annual Report of the Board of Regents of the Smithsonian Institution, for the year ending June 30, 1900.* Pp. xlv, 759. Washington, 1901.—The Annual Report of the Smithsonian Institution, recently published, includes in its preliminary part the Report of the Secretary, Professor S. P. Langley, which was issued earlier in separate form, and has been noticed on page 400 of the May number. The remainder of the volume is occupied with the general Appendix, which contains reprints of a well-selected series of papers, on topics ranging from astronomy to medicine, and all calculated to be of great interest to the ordinary reader as well as to the scientist. With its other important functions, the Smithsonian Institution does a valuable work in thus presenting to the public well-digested reviews of the progress of science in its different departments and also in republishing articles which would not otherwise be readily accessible. Of the subjects here included, one of particular interest is an account, liberally illustrated, of the Langley Aërodrome, and another on the Zeppelin Air Ship accompanies it. A complete list of the papers printed in the volume would be required to show their range of subject and individual importance.

3. *The Smithsonian Institution: Documents relative to its Origin and History, 1835–1899;* compiled and edited by WILLIAM JONES RHEES, in two volumes. Vol. I, 1835–1887. Twenty-fourth Congress to Forty-ninth Congress. Pp. liii, 1044. Washington, 1901.—The very interesting volumes relating to the history and work of the Smithsonian Institution, presented to the public some years since (1879, 1896) are now followed by the republication in full of all the public documents which relate to

its inception and history. The volume now issued covers the period from 1835 to 1887.

4. *Beiträge zur Chemischen Physiologie und Pathologie*—Zeitschrift für die gesamte Biochemie; herausgegeben von Franz Hofmeister, o. Professor der physiologischen Chemie an der Universität Strassburg. Braunschweig. (Fr. Vieweg und Sohn. Two volumes per year; price 15 marks for each volume of 12 numbers.)—The progress of recent years in various branches of biology and medical science has been particularly characterized by the growing interest in the chemical problems involved, and the increased application of chemical methods for their solution. The rapid development of physiological chemistry is indicated by the beginning of a new journal devoted to original investigations of bio-chemical nature. In addition to the presentation of more exhaustive contributions, it is proposed to afford a medium for the speedy publication of briefer communications regarding new discoveries, etc. Under the editorship of one of the most active workers in this field, a successful future for the new publication is assured; and the scientific papers printed in the three numbers already published give evidence that the "Beiträge" will form a part of the permanent literature of biology.

Contributions may be directed to the editor, Wimpfelingstrasse, 2, Strassburg i. E. L. B. M.

5. *Annals of Harvard College Observatory.*—Recent publications include the following:

Vol. XXVIII, Pt. II; Spectra of Bright Southern Stars; Photographed with a 13-inch Boyden Telescope, as a part of the Henry Draper Memorial, and discussed by Annie J. Cannon, under the direction of Edward C. Pickering, Director of the Observatory. Pp. 131–263, with three plates.

Vol. XLI, No. VII. Comparison of Results obtained with different forms of Apparatus in Meridian Observations; by Arthur Searle. Pp. 189–211.

6. *Royal Society of London.*—The Copley Medal has recently been awarded by the Royal Society to Professor J. Willard Gibbs of Yale University, New Haven, for his contributions to mathematical physics.

Obituary.

Rudolph Koenig, the well-known investigator in acoustics and skillful maker of acoustical apparatus, died at Paris on October 2, at the age of sixty-eight years.

Professor A. F. W. Schimpfer, the eminent botanist, died on September 9 in his forty-sixth year.

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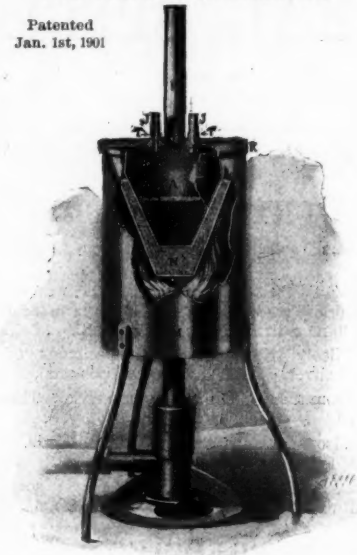

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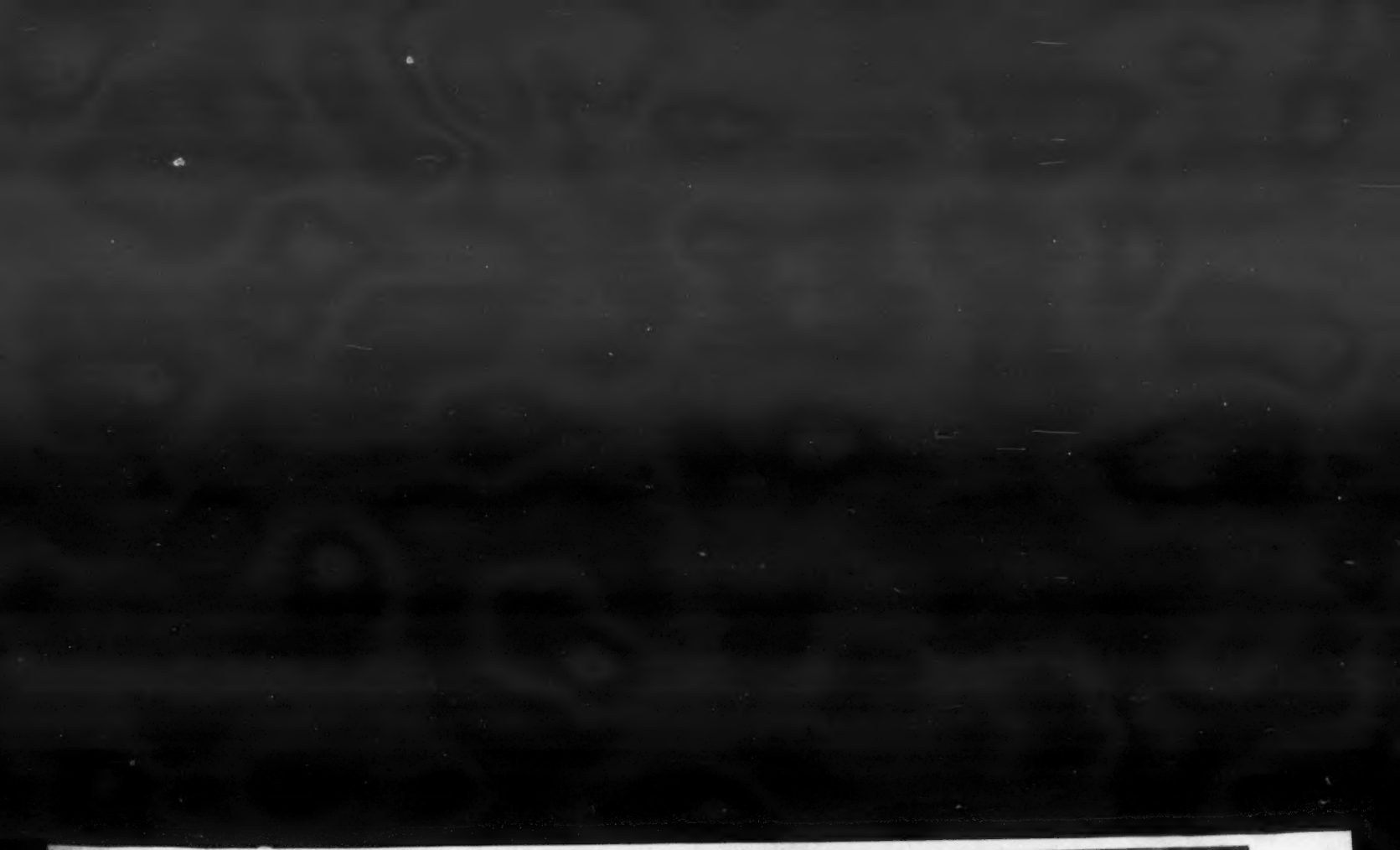
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